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ABSTRACT

Energy education units (consisting of a general teacher's guide and nine units containing a wide variety of energy lessons, resources, learning aids, and bibliography) were developed for the Indiana Energy Education Program from existing energy education materials. The units were designed to serve as an entire curriculum, resource document, supplementary materials, or as a laboratory manual of "hands-on" activities which could be infused into existing grades 9-12 curricula. Unit VI, focusing on fossil fuels and energy alternatives (solar and coal), consists of an introduction (rationale, unit objectives, and general background information), eight "solar lessons," three "coal lessons," unit resources, bibliography, and teacher evaluation form. Each lesson includes lesson title, objectives, background information, activities, evaluation techniques, and resources. Titles of solar lessons are: (1) All Buildings Are Solar Collectors; (2) The Cardboard Carpenter and the Solar Hot Plate; (3) A Green/Ice House; (4) A Wet Solar Collector; (5) The Sunshine Papers (drawing and designing a solar plate collector); (6) Color Conduction Comparison; (7) Wind Generator; and (8) Second Hand Solar Sources: Savonius Rotors. Coal lesson titles are: (1) Coal and Energy; (2) Types of Mining and Mines; and (3) Problems with Coal and Solutions. (Author/JN)

LESSONS from An Energy Curriculum for the Senior High Grades

Unit VI — Fossil Fuels and Energy Alternatives (Solar, Coal)

Indiana Department of Commerce
Lt. Governor John M. Mutz, Director

Indiana Department of Public Instruction
Harold H. Negley, Superintendent

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LESSONS FROM AN ENERGY CURRICULUM

FOR THE SENIOR HIGH GRADES

Unit VI -- Fossil Fuels and

Energy Alternatives (Solar, Coal)

Division of Energy Policy
Indiana Department of Commerce
Lt. Governor John M. Mutz, Director

Division of Curriculum
Indiana Department of Public Instruction
Harold H. Negley, Superintendent

April 1982

FOREWORD

Indiana educators have always responded to the demands placed upon them by society to resolve natural and human resource issues and problems. The task of teaching energy concepts and conservation practices to Indiana's youth is a response to energy problems facing our state and nation. It will be accomplished by many high school teachers and students getting involved in energy education.

We feel that students of all ages must be taught an energy conservation ethic. This ethic will enable each student to use Indiana's and America's energy resources more efficiently and with less waste. To help high school teachers accomplish this major goal, we are pleased to introduce a new Senior High School Energy Education Curriculum. This exciting and innovative program contains energy education activities, programs and resources for you and your students.

We encourage you and your students to get involved in the lessons presented here We hope you will use these materials as a starting point and go far beyond by involving other classroom teachers, students, resource agencies and citizens in your community. A broad educational effort is needed to help prepare students to deal with this growing issue which affects us all.

Harold H. Negley
State Superintendent of
Public Instruction

John M. Mutz
Lieutenant Governor
State of Indiana

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The Energy Education Curriculum Project is coordinated by the Indiana Department of Public Instruction, Division of Curriculum, with the support and assistance of the Indiana Department of Commerce, Division of Energy Policy.

These materials, from the senior high grades segment of the Energy Education Curriculum Project (EECP), were adopted from existing national energy education programs. The materials were selected by the EECP staff with assistance and direction from a Review Panel and the Energy Education Steering Committee.

The materials included in this unit of the senior high segment of the Energy Education Curriculum Project (EECP) were adapted with permission from:

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George Cannon, Patricia Shutt and Joe Wright, Energy Education Consultants, coordinated and supervised the preparation, evaluation and dissemination of these energy education materials. Carol Wood, Teacher Associate, assisted the EECP staff with the design and dissemination plans for the materials.

Members of the Senior High Energy Education Steering Committee are -- John A. Harrold, Director of the Division of Curriculum; Darrell Morken, Director of the Division of Traffic Safety; Gary Geswein, Agribusiness Education Consultant; Jerry Colglazier, Science Consultant, Joyce Konzelman, Home Economics Chief Consultant; Jane Lowrie, Social Studies Consultant; Victor Smith, Research and Evaluation Coordinator; Gregg Steele, Industrial Education Consultant.

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Unit VI

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INTRODUCTION
(Rationale)

ENERGY EDUCATION - WHAT IT IS - Past, Present, Future

Energy education is the attempt to resolve the conflict between our present life style and the energy costs in both dollars and resources to produce and maintain that life style.

Energy education is reality education in that it deals with what exists here and now.

But energy education is also a study of futuristics. The future that all of us must be willing to live in and accept is the one that we are creating right now by our daily decisions. We must examine the beliefs that "growth is good" and "bigger is better" and determine the impact these beliefs will have on our future.

Energy educators interested in the challenge to teach students about local, state, national and global energy resources, problems and issues should consider the the following questions:

1. Can you help prepare your students to make wise and careful decisions about our remaining now-renewable energy resources?

2. Can you help prepare them to investigate and make wise decisions about research and development efforts for alternate and renewable resources, recycling programs, more efficient transportation systems, better personal consumption habits, and a personal commitment to efficient energy usage?

3. Can you explain to your classes where energy comes from, what the basic sources of energy are, how long our non-renewable energy resources will last, and the energy options among which our nation's people must choose if we are to survive.

The three questions above suggest that energy education is a challenge which encompasses all facets of living. Energy education is an opportunity for students to have impact on a long-lived problem, an opportunity to apply traditional content and skills to an important problem situation, and an opportunity for students to participate in personal and social decisions.

WHY STUDY ENERGY?

"One of the best ways to deal with a crisis is to consider it as an opportunity. From this point of view, the energy crisis provides almost endless possiblities for children to learn about themselves. Energy after all is what makes all things go. We need to realize that the energy crisis isn't just the newest fad.

By studying the energy crisis, students can see where humanity has been, where it is now, and where it might be going. The energy crisis is another chapter in the story of mankind's continuing effort to reshape the world and the inevitable cost of doing that."[1]

To ensure proper utilization of energy sources, our society must be educated about alternate life styles, energy resources, technology, consumer behavior and occupations.

The Indiana State Department of Public Instruction, in cooperation with the Department of Commerce, Division of Energy Policy, has organized the Energy Education Curriculum Project (EECP) to meet the challenge of educating young people (our future adults) about energy, the energy crisis and the role they can play to help conserve America's economy and resources.

One way the Energy Education Curriculum Project staff has dealt with the task of disseminating energy information and education is through the Indiana Energy Curriculum Units. The units have been organized to help provide educators in many areas with lessons, charts, materials and "hands-on" activities to be used in the classroom.

[1]Quote taken from: The Science Teacher -- September 1978.
Article: "Teaching the Energy Lesson"
Author: David J. Kuhn

The Curriculum - Background Information

The Energy Education Units contained in the Senior High School materials were adopted from existing national energy education materials. A team of teachers from Indiana reviewed and evaluated energy documents from across the nation, and only those activities or lessons which proved to be most effective in educating students were chosen for Indiana's program.

The units are designed to be used as the individual teacher wishes. The energy units could be used as an entire curriculum or as a resource document, supplement or laboratory manual of "hands-on" activities which can be infused into already existing curricula.

The Indiana Energy Education materials for grades (9-12) consist of a Teacher Guide, nine units containing a wide variety of energy lessons, resources, learning aids and a bibliography.

Unit VI

Unit VI, entitled "Fossil Fuels and Energy Alternatives," is composed of lessons dealing with energy alternatives, solar and coal. The lessons contained in Unit VI contain a variety of instructional methods to be used in acquiring working knowledge about the sun and coal as energy resources.

Unit Objective

The student will develop an understanding of how the sun and coal can be utilized as energy efficient resources. The student will be able to explain problems and opportunities associated with solar energy and the burning of coal and recommended possible solutions to the problems.

The student will support and practice wise utilization of coal resources and support expenditures for research and development of efficient surface mining operations, reclamation practices and solar operations and methods.

Introduction
(Continued)

Background Information

In this age of excessive costly energy consumption and environmental pollution (as a result of energy production), society is in the process of seeking out various alternatives in the production and consumption of energy. There is a growing concern with the energy crisis and the environmental quality that is maintained. Therefore, many methods and ideas have been explored dealing with how energy can be used more efficiently and with the development of new energy resources.

Unit VI explores both of these avenues, by presenting to the reader a wide variety of hands-on activities for students to construct solar models, conduct research on coal, methods of mining, and environmental impacts that coal production might have. By using Unit VI students will understand the importance of energy self-sufficiency and a clean environment.

Unit VI

Lessons A-H (Solar)

LESSON TITLE: All Buildings Are Solar Collectors

LESSON OBJECTIVE

Students will be able to determine the effect of shading a south window with an overhang on the temperature inside a room by constructing a model "house" and taking measurements.

BACKGROUND INFORMATION - See Attached

ACTIVITIES - See Assignments Attached

RESOURCES - Resources are listed at end of lesson

BACKGROUND INFORMATION

It is estimated that one-half of the energy consumed by buildings in the United States is wasted. Until recently, few of us have thought about the interaction of buildings and their environments. Our recent concern about the influence of environmental forces such as sun, wind and rain on building design reflects both a growing interest in environmental quality and the emergence of the energy crisis. These two issues - the desire for energy-sufficiency and a cleaner environment - merge into a tremendous challenge for architects, designers, planners and home builders.

Energy and demand can be reduced by two strategies. The first is to reduce energy demand by using energy more efficiently and eliminating unnecessary energy uses. Energy conservation is the cleanest, cheapest and most readily available source of energy. The second is to develop new supplies of energy - such as solar or wind - to supplement the declining supplies of traditional fuels.

In the last few decades designers of buildings have paid little attention to climatological impacts preferring, in the words of Marguerite Villecco, to "meet requirements for human comfort by brute mechanical force. These buildings have contributed to the energy crisis today, not by intent but by circumstance; they were designed according to economic and resource mores that no longer exist."[1]

For a growing number of designers and builders interest in using energy inputs of the natural environment to flatten the temperature curve of the internal environments of modern buldings embraces more than the strategies described above to lesson demand, namely conservation and the development of new energy sources.

This new consciousness is "the integration of energy conscious approaches into building forces responsive to human, energy and environmental criteria. Instead of buildings with solar energy systems, the best of these are solar buildings. This is not just a game with words; it is a significant difference in building design."

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[1]Design Quarterly 103, p. 4.

Passive solar systems are simple. They are at least as old as the Pueblo Indian's adobe structures which appeared in New Mexico around 800 A.D. Thick adobe walls absorbed the sun's heat by day and then radiated this warmth by night. One of these, Pueblo Bonito in Chaco Canyon, contained approximately 800 rooms and at one time housed over 1,000 people, making it the largest North American apartment house ever built until the 1890's, when a New York City multiple dwelling surpassed it. The Pueblos were "the product of an early solar age - when trees (biomass) and masonry (passive solar collectors) - were among the only ways man could warm his world. Twelve centuries later, dwindling fuel supplies and environmental pollution are motivating Americans to work out how they might return to a solar age." (Janet Raloff, Science News, April 22, 1978, p. 267).

There is still much to be learned about why and to what extent certain materials store - and later reradiate - heat. One of the experimental solar buildings at MIT is entirely passive and relies on synthetic materials which contain a core of Glauber's salt (Science News, January 7, 1978, p. 8) and other chemicals which can store a day's heat gain and then release it as needed. The core acts as a thermal regulator - a natural thermostat set at 73 degrees. As heat is radiated, it freezes into a solid; the following day as it absorbs heat, it melts back to a liquid.

What is a reasonable expection for solar heating and cooking in home design? Peter van Dresser, a solar heating experimentalist, stresses that we sould think of such houses as " sun-tempered" rather than "solar-heated." He has pointed out that performance standards of a solar home are likely to be different from the standards we have come to expect from gas, oil, coal or electrically heated homes.

The emerging debate on solar has been hinted at several times in this introduction. Bruce Anderson, an architect and author of a widely acclaimed book on solar energy has written specifically about this as follows:

> The use of solar energy is at a crossroads. It can be used in ways that perpetrate the status quo and hasten the demise of an overexploited environment, or it can be used in ways which will enrich our lives and bring us closer to our natural surroundings. I hope my book will help us to walk this latter path.
>
> Some people might think it rather dull to let sunlight in through the windows and keep it there, but others of us delight in the simplicity of this approach. In fact, conserving the sun's energy can often by more challenging than inventing elaborate systems to capture it.

Bruce Anderson, 1976, p. 77

What is the effect of shading a south window with an overhang on the temperature inside a room? To find out have students construct a model "house" and take some measurements.

Activities

THREE OPTIONS

Materials needed for this activity incl_de:

Cardboard boxes: assorted sizes and shapes
Paints: flat black, assorted colors
Window glass: 4X6"; 8X10"
Clear plastic wrap
Thermometers
Graph paper
Masking tape
Knife
Flat cardboard
Rulers (with metric measurements)
A sunny day!
Compass
Protractor
Graph paper
No clouds!
Lightbulbs: 100-150 watts

There are three options listed. They are briefly summarized in the table below. The required measurements are listed after the descriptions of the three options.

A SUMMARY OF ROOF OVERHANG ACTIVITY OPTIONS

OPTION	LOCATION	BEST TIME	INSTRUCTIONS
1	Outside/ sunny window	9:00 am-3:00pm 12:00 noon best	Students develop their own solution to the problem.
2	Outside/ sunny window	9:00 am-3:00 pm 12:00 noon best	Specific instructions for construction of a model and measurements of a roof overhang are given.
3	Inside	Anytime	The angle of the sun on a window and overhang of a model "house" is simulated, in a rough sort of way, by means of lightbulbs.

Option 1

Challenge your students to design and construct a box with a window in it which shows the influence of a roof overhang on the air temperature inside the box. The box can be considered a model of a house. It does not have to look like or be an architectural model.

They go outside, take some measurements and reach some conclusions based on their findings. The glass side of their model is to face south when they take these measurements.

NOTE

Obviously, they may need some help with such an open assignment. The materials will give them some clues but you will have to help them make decisions. This option requires a healthy respect for the value of mistakes!

Do your students know what a roof overhang is? What evidence do they have from their experience that heat gain through windows can be reduced in the summer and increased in the winter? Are there any houses in their community which have awnings? Are they permanent or temporary? Do any stores in their community use awnings? What is their function? Are there any houses in their community with prominent roof overhangs over south facing windows? Is there a reason for this kind of design?

Would it be possible to find out the function of an overhang by making a model and taking some temperature measurements? It is important that students realize that this model is not a scaled, architectural model but simply a cardboard box with a glass window to which the inside of the box can be exposed to the sun. The window can be shaded by a cardboard overhang on top of the box.

Students will have to decide:

1. How they will place the window in the box.
2. Whether the box need to be reasonably well sealed or not.
3. How will they take the air temperature inside the box.
4. Whether it is important for them to know the temperature outside the box.
5. How to record the temperature information they collect. Does it make any difference whether the window is completely shaded or not for their first air temperature measurement? How many measurements do they need to take to prove that the overhang makes a difference? To do this, does the overhang need to be moved? Does it have to be graphed? If so, what units go on the x-axis (up the paper); what units go on the y-axis (across the paper)?

6. Whether the roof overhang has to be movable or fixed.
7. How they know that the window, the glass side, is facing south.

When they are finished discuss the results. Do their findings suggest that roof overhangs work? You may want to use the questions (AFTERWORDS) at the end of the activity.

Some of the student models may have worked better than others. Try to find out why, but be careful that the models are compared and not the students. You may want to summarize the activity by arriving at a model incorporating those features which best answer the question on the effectiveness of roof overhangs. It could also be of some value to summarize the measurement steps.

Option 2

Procedure:

1. Use a square cardboard box about 1 ft., by 1 ft., by 1 ft.

2. Make an opening for a window in one side of the box.

3. Paint the inside flat surfaces black.
   Paint the outside roof surfaces white.

4. Mount the glass window with masking tape.

5. Make an opening in the back side of the box 2-3" from the top so that a thermometer will just fit.

6. Insert the thermometer so that it can be used to read the inside temperature from the oustide. The bulb should not be exposed to any direct sunlight (Why?).

7. Use a cardboard sheet as a roof overhang. Tape it in place or hold it in place by weights. A ruler should be mounted on the cardboard so that you can read the amount of the roof overhang directly.

8. Record the outside air temperature when you take your measurements.

Option 3

Construct a model "house" similar to the one described in Option 2. A lamp is used to simulate the sun. You and your students may want to construct the model from plywood so that it looks more like a house. The overhang could be made so that it slides in grooves. You and your students will have to "mess around" to find the best distance of the lightbulb(s) from the model "house." Two bulbs could be mounted permanently to simulate the altitude of the sun on June 21 and December 21.

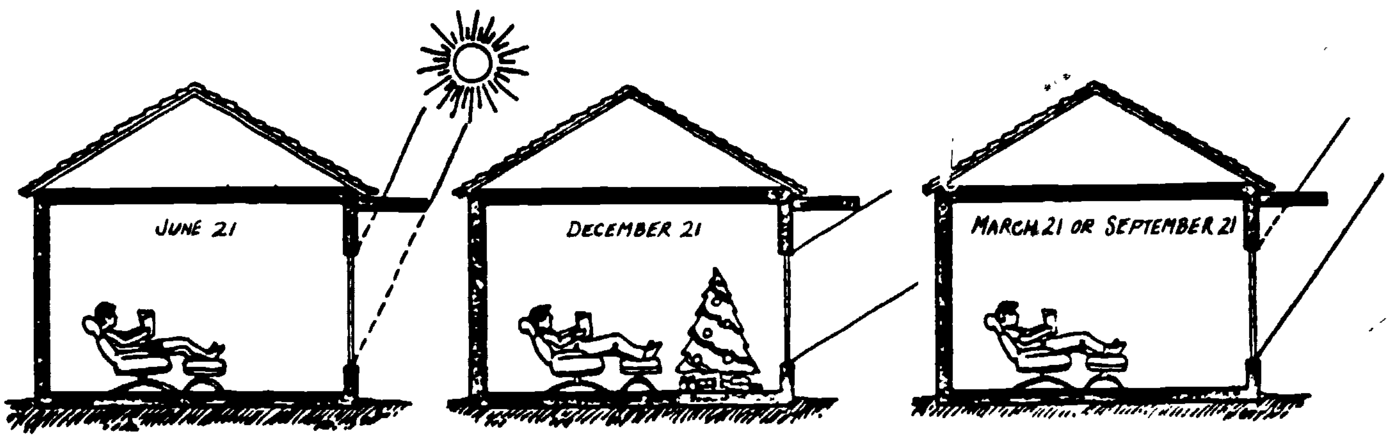

Figure 1. Working with the sun: shading a south-facing window with an overhang (from Anderson, "The Solar Home Book", p. 87.

Solar altitude (ALT) positions for ______________ may be found in Table 1. You are to assume that the window is facing south.

Table 1. Solar Positions (Rounded to Nearest Degree) for 48° North Latitude, 12 Noon

Angle	Jan 21	Feb 21	Mar 21	Apr 21	May 21	June 21	July 21	Aug 21	Sept 21	Oct 21	Nov 21	Dec 21
ALT	22°	32°	42°	54°	62°	66°	63°	54°	42°	32°	22°	19°

Source: Morrision, C.A. and E.A. Farber. 1974. Development and Use of Solar Insolation Data in Northern Latitudes for South Facing Surfaces from "Symposium on Solar Energy Applications," ASHRAE, New York.

THE BASIC MEASUREMENTS

GO OUTSIDE: HIGH NOON

1. Place the model with the window facing due south.
2. Slide the roof overhang out so that no direct sunlight reaches the window.
3. After the temperature has stabilized record the temperature.
4. Move the roof overhang back by a fixed amount (1 inch, 1cm). Let the temperature stabilize and record it. Repeat this step until there is no overhang.
5. Graph your information.

AND MORE, IF YOU WANT

1. Do this in September, October, November, December, January, February, March, April and May or once in the Fall, Winter and Spring.
2. Try this experiment inside if you have sunny classroom windows.
3. Record the temperature every 30 minutes for a day. Start with a roof overhang that just covers the glass with shade at noon. Then compare your temperatures with these roof overhangs: no window shadow at noon; ¼ window shadow at noon; ½ window shadow at noon; 3/4 window shadow at noon.
4. a. The horizontal overhang is one shading possibility. Many solar designed homes also make use of vertical fins on the sides. Place vertical fins on the model. At about 8:00 A.M., with the window facing south, take the same temperature measurements that you did for the horizontal overhang.

   b. Take temperature measurements every 30 minutes during the day for vertical fins.

AFTERWORDS - Questions to Ask

1. Based on your measurements what is the appropriate amount of roof overhang to let sunlight in when the house needs heat and keep sunlight out when it dosen't?

2. Based on your measurements what is the best combination of roof overhang and vertical fins to let sunlight in when the house needs heat and to keep sunlight out when it doesn't?

3. a. You have been asked to design a louvered overhang that adds heat in the winter and prevents heat addition in the summer. What design features would you need to consider?

   b. Would you need to consider the angle of the louvered materials if the overhang was covered with a climbing vine? Why or why not? What are some of the advantages and disadvantages of such a solution?

   c. You are working in an architectural office. Which kind of overhang (3a or 3b) would you recommend to a client? What are your reasons? Does is make any difference?

4. In what ways would a roof overhang on south-facing windows reduce energy consumption in a home?

5. Which provides better shading to minimize summer heat gain and maximize winter heat gain: a fixed overhang or trees or a combination? What are some factors which need to be considered in reaching your decision?

RESOURCES

Anderson, Bruce with Michael Riordan. 1976. The Solar Home Book: Heating, Cooling and Designing with the Sun. Cheshire Books, Harrisville, New Hampshire.

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SHELTER I. 1973 ($6.50).

SHELTER II. 1978. ($10.00). Shelter Publications, P.O. Box 279, Bolinas, California. World-wide housing techniques...conventional housing to the less-conventional. Each book features energy design considerations.

Villecco, Marguerite. 1977. Architecture as Energy. Design Quarterly 103 (Walker Art Center, Vineland Place, Minneapolis, MN 55403): Excellent background. A baker's dozen design projects which represent a sensitivity to the sun, "that limitless, free resource."

LESSON TITLE: The Cardboard Carpenter and The Solar Hot Plate

LESSON OBJECTIVE

The students will build a low cost experimental flatplate solar collector.

BACKGROUND INFORMATION - See Attached

ACTIVITIES - See Assignments Attached

RESOURCES

Resources are found at end of lesson

DIAGRAMS

Diagrams are found at end of lesson

THE CARDBOARD CARPENTER AND THE SOLAR HOT PLATE

BACKGROUND

Solar heating methods can be grouped into three general categories - direct, integrated and indirect. In direct solar heating, the sun's rays penetrate directly into the home. The heat absorbed by internal structures such as concrete floors and adobe walls is released when the sun is not shining. This is the simplest method of solar heating.

Integrated solar systems make use of materials which collect and distribute heat to the house with a minimum of mechanical power devices to transfer the heat collected. These systems are also called passive systems. Passive systems, while simple, often result in structures that depart from standard construction practices. Indirect solar systems make use of solar collectors, separate heat storage facilities and pumps and/or fans to circulate liquids or air through the collector and heat storage containers. Indirect systems tend to be more readily applied to existing homes.

Indirect solar heating systems use flat-plate collectors to collect solar energy. The collectors, which contain a black absorber, are covered with one or more glass or plastic covers. The cover plates reduce heat loss through the front of the collector. Insulation material is usually placed beneath the absorber to reduce heat loss through the back of the collecter. Heat from the absorber is transferred to either air or liquid which, as it flows, carries the heat to the desired location in the house.

DESCRIPTION

You will probably want to point out some differences between a model corrugated cardboard collector and more permanent collectors. A window or roof solar collector designed for permanent outdoor use would be made from more durable materials such as wood or, most often, metal.

While this project can be built in almost any classroom, a sheet metal squaring shear would be very helpful for cutting the cardboard. Corrugated cardboard cuts extremely well on a properly sharpened squaring shear. Also, by using a squaring shear, the cardboard can be cut fast and accurately, and the hazards of cutting with a knife is reduced. Some cutting with a knife or saber saw will be necessary for the cut-outs and for final trimming.

MATERIALS LIST

Corrugated Cardboard - Refrigerator cartons work very well. Use the heaviest cardboard available, ¼ to 3/8 inch thick.

Cutting Knives and Blades - For cutting and trimming. The Stanley #199 Utility knife or General #850 Utility knife work well.

Glue - Water glass (sodium silicate) or, if unavailable, white glue.

Paint Brush - 1", for brushing on the glue.

Aluminum Foil - Rolled, 18" wide.

Aluminum Printing Plate - Available from many printing or newspaper shops. Size: approximately 15¼ x 22 inches.

Cellulose Insulation - Approximately ¼ pound per unit.

Polystyrene Insulation such as a ½" ceiling panel - Dimensions: 16 x 17 3/4".

Polyethylene (or other clear plastic) sheet - Dimensions: .004 mil x 15½ x 17".

Gummed tape, Brown Kraft, 2-2½" wide.

Masking tape - 1" wide.

Flat Black Paint

Thermometers

Milkweed pod

Activities

PROJECT CONSTRUCTION

1. Cut the front, back, and two sides to size from corrugated cardboard. Use the thickest cardboard available (Fig. 1).

2. Fasten the front, back, and two sides together with gummed tape.

3. Cut top and bottom pieces to size. They should be equivalent in size to the outside dimensions of the main box. (fig. 2).

4. Attach the bottom to the main box with gummed tape.

5. Cut a ½" thick foam or expanded polystyrene panel to fit inside the collector. Other insulation can be substituted, as long as the bottom of the collector is insulated.

6. Glue aluminum foil onto the top side of this lower insulated panel. Use water glass (sodium silicate) or, if it is unavailable, white glue diluted with water so that it can be easily brushed on.

7. Glue or press fit this panel in place at the bottom of the main box.

8. Cut the cardboard pieces for the insulated center panel. Glue the spacers around the perimeter of the bottom piece of this center panel, and fill with cellulose insulation. Attach the top to finish this center panel construction. (Fig. 3).

9. Glue aluminum to both sides of the center panel (shiny side facing out).

10. Next, cut and attach the supports for the center panel. One ½ x 15½" strip of corrugated cardboard (or wood) is attached on the inside of each side piece. They should be 4 inches from the top and should be positioned to just touch the front panel. (Figs. 1 & 2).

11. The insulated center panel can now be inserted in place. Stops can be attached to prevent this panel from sliding to the back of the collector when the collector is tilted. (Fig. 2).

12. Tape one layer of plastic sheet (.004 mil works well) to the top piece using masking tape. (Fig. 4).

13. The solar plate (from aluminum printing plate) is made by alternately bending the aluminum into 1¼ inch segments. (Fig. 4).

14. Paint the solar plate by brushing on flat paint (both sides).

15. Install top of collector.

TEST PROCEDURES

The completed collector can now be tested. Have students place their collectors directly in the sun. Air will be drawn in through the small hole in the front panel. The size of this hole will have to be adjusted by trial-and-error. Air drawn in through this small hole will sink underneath the center panel and rise at the back of the collector. The heated air on the top of the center panel will rise and move out of the large opening in the front panel. Because the collector is rather small, it may be necessary to close off the holes partially or completly on a very cold day.

1. Ask your students to devise a way to show that air is moving through the collector. The parachute seeds (called coma) from a milkweed pod, small pieces of cellophane or fine dust are some possibilities. They must be able to convince you that the device is moving the air and not anything that they are doing to it.

2. Ask your students to take some temperature measurements. Measure and record the temperature every minute until the maximum temperature is reached. Plot temperatures versus time. How much variability is there in the class in the maximum temperature outcomes? How much variability is there in the amount of time it takes for collectors to heat up to the maximum temperature? What are some of the causes?

3. Ask students to modify their collectors to see whether they can produce a better performance. You may have to help them decide on what makes a better performance. Be sure that they devise a way of measuring this better performance.

This project can be duplicated with a larger version of the same collector. By putting the front in an open window, air will be drawn out of the room and down to the back of the collector. Heated, it will rise up and enter the room. (Fig. 5).

A solar collector of this type can be used in building construction classes. With slight modifications the collector can be attached to a building mockup and measurements can be taken.

RESOURCES

Anderson, Bruce with Michael Riordan. 1976. The Solar Home Book: Heating, Cooling and Designing with the Sun. Cheshire Books, Harrisville, New Hampshire ($8.95).

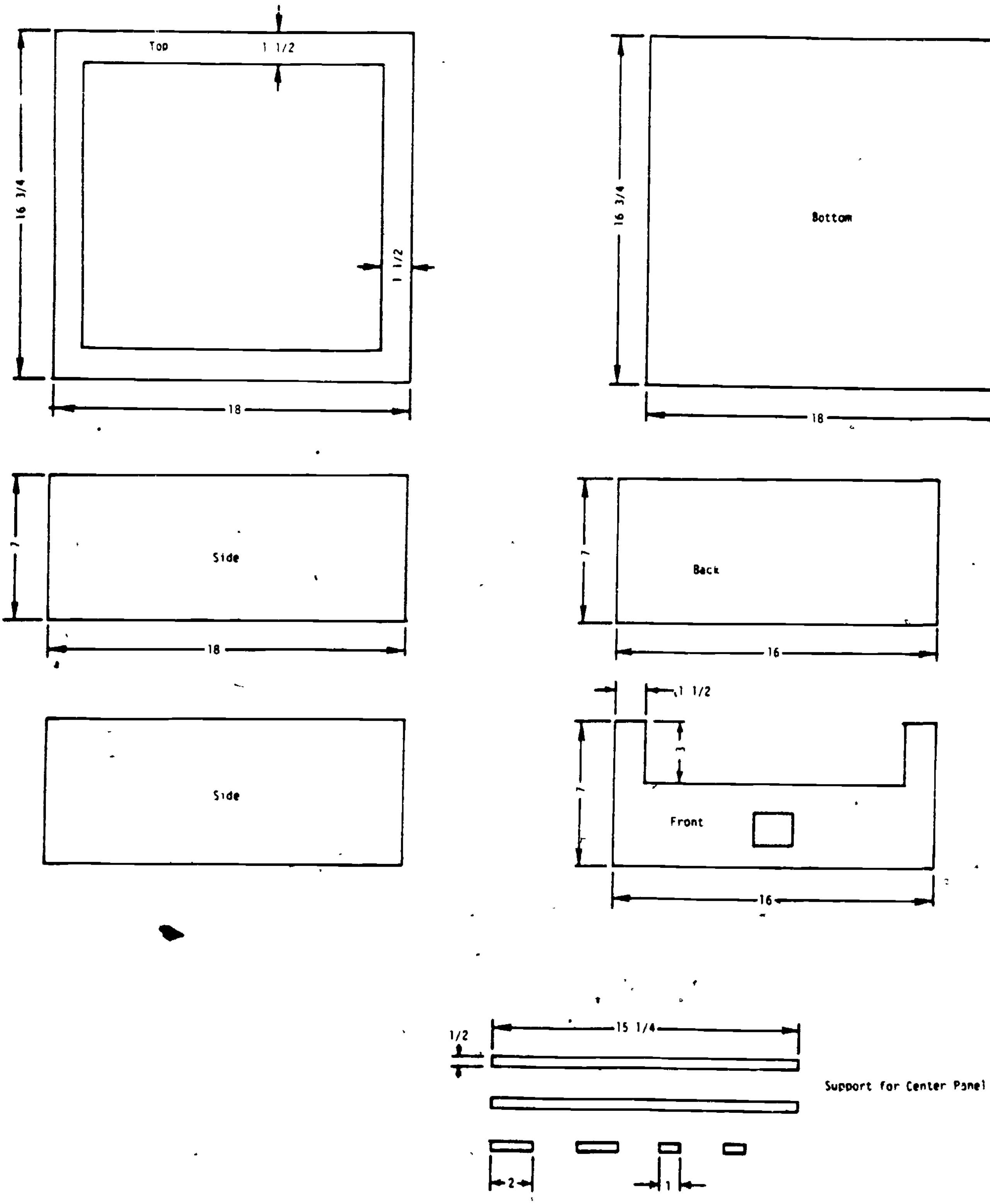


Figure 1. Cardboard layout for the main box.

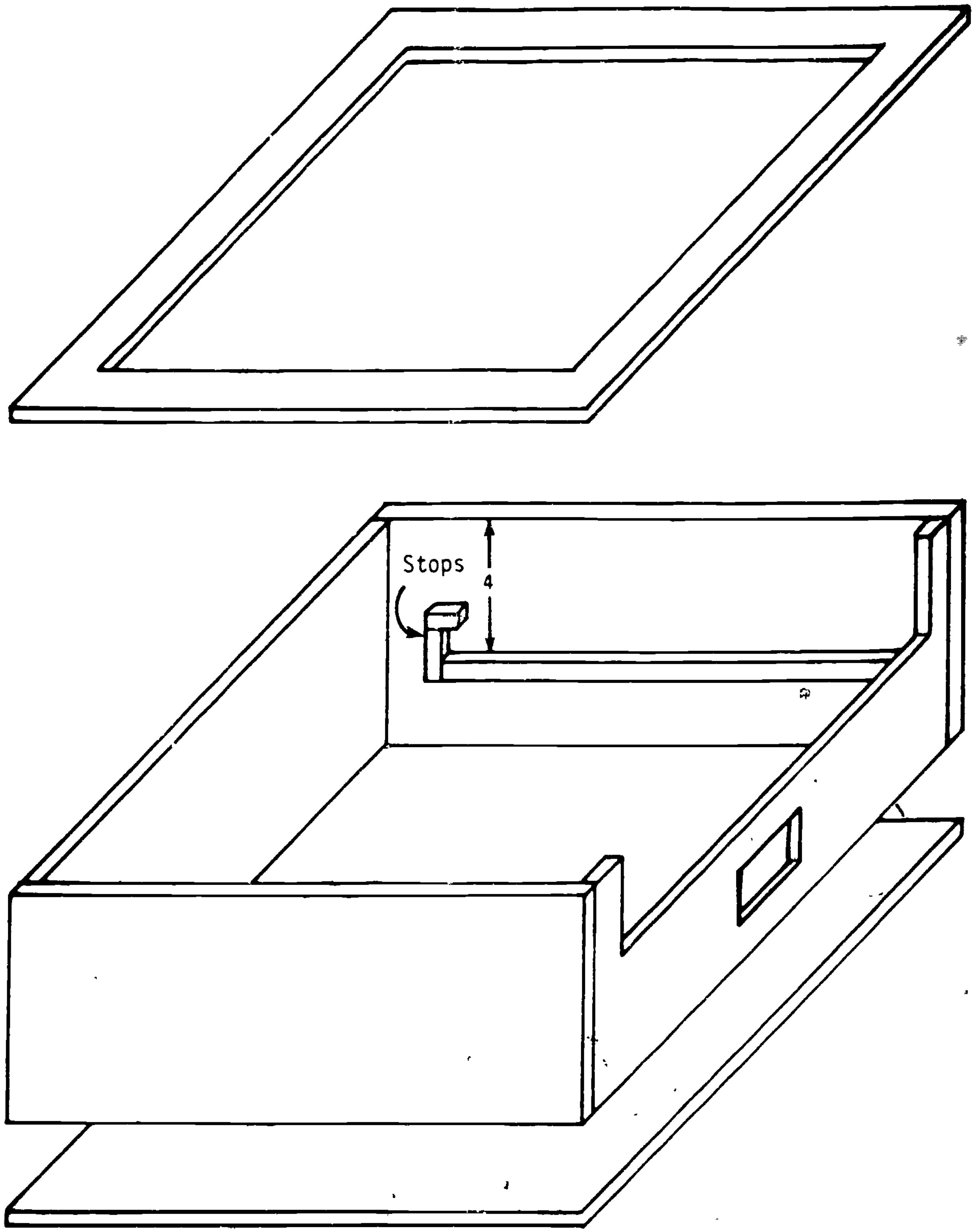
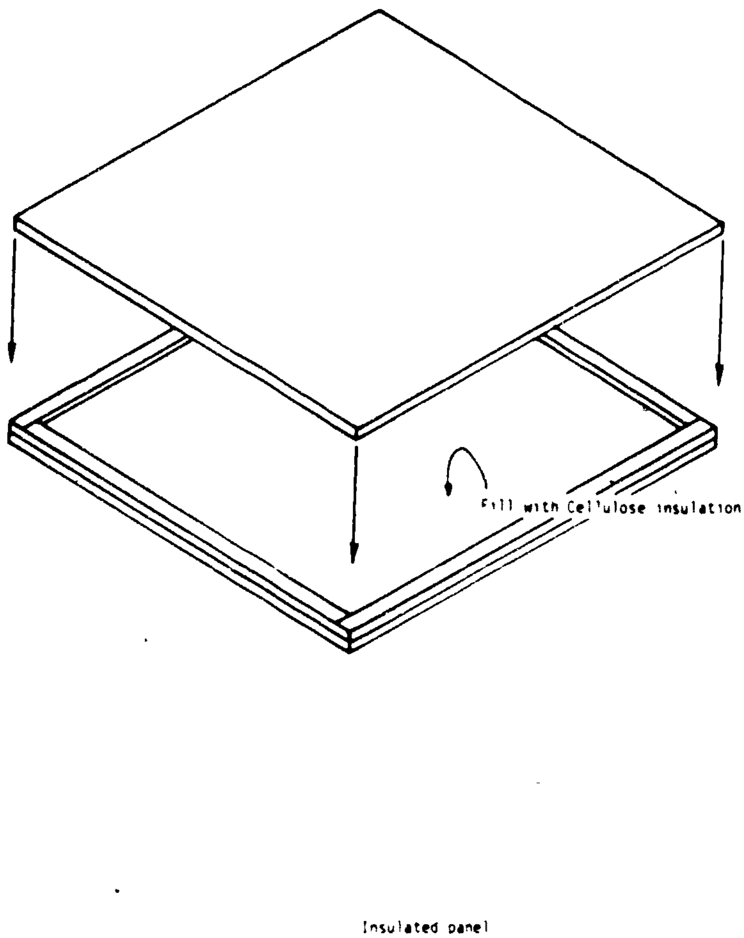


Figure 2. Assembly of the main box and position of center panel supports.



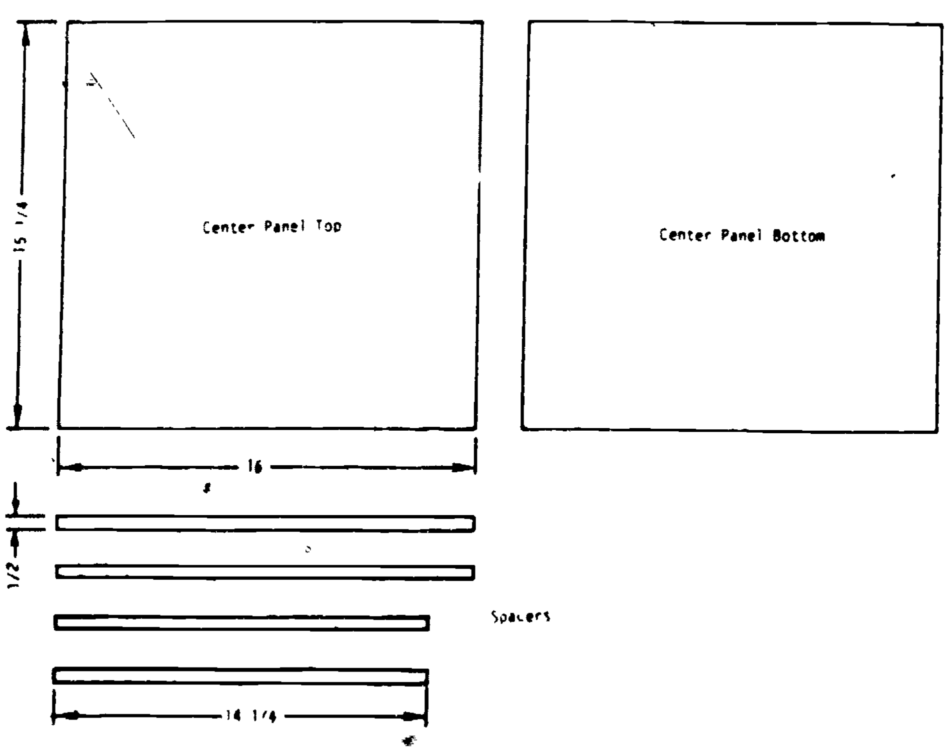


Figure 3. Insulating the center panel.

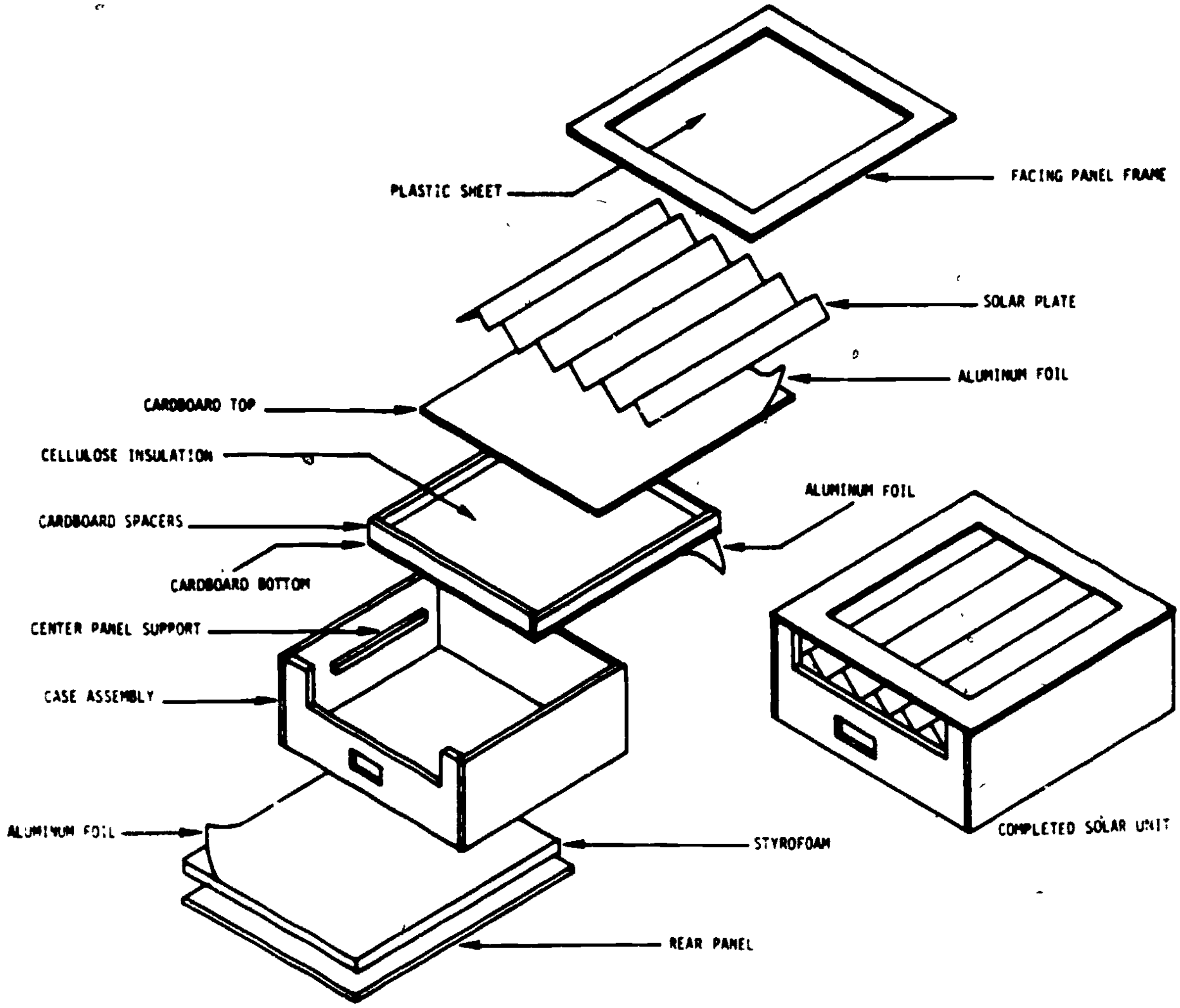


Figure 4. An "exploded" view of the solar unit.

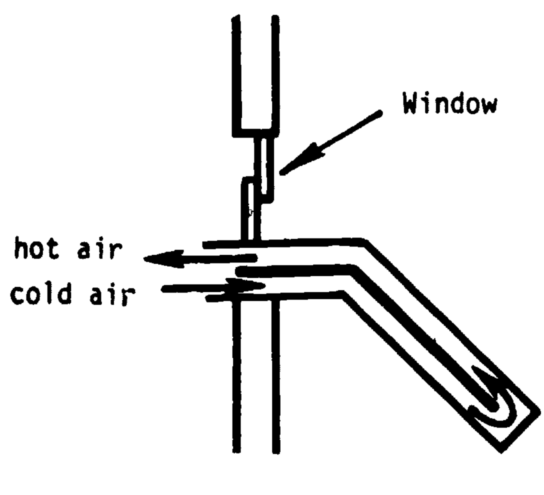


Figure 5. A solar collector attached to a window.

LESSON TITLE: A Green/Ice House

LESSON OBJECTIVE

Students will use the "greenhouse effect" to make a warm greenhouse for growing vegetables, or make a light, portable ice-fishing house for the winter out of salvaged and inexpensive materials.

BACKGROUND INFORMATION - See Attached and Figure 1

ACTIVITIES - See Project Construction

RESOURCES

Resources are listed at end of lesson

A GREEN/ICE HOUSE

BACKGROUND INFORMATION

When the sun's rays shine through a window, the objects in the room are warmed. The objects then emit, or give off, long-wave (heat) radiation. The glass window does not let these long waves go back out. That is how the window "traps" the sun's rays. This kind of window is called a passive solar collector. That is, no additional energy is needed to operate pumps, fans, or other electrical devices. The heating process is known as the greenhouse effect.

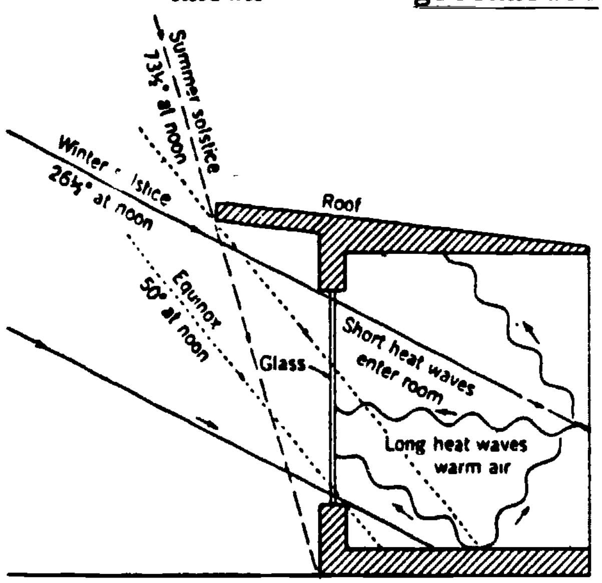


Figure 1. Passive solar heaters use the greenhouse effect. In summer, the roof overhang excludes the summer sun; in the winter it admits the winter sun.

1979

Trial Energy Materials: Industrial Arts

Minnesota Department of Education, Minnesota Energy Agency
Minnesota Environmental Education Board

DESCRIPTION

In order to make the lightweight, inexpensive greenhouse shown - or icehouse - your students will need some 2" x 2" lumber and plastic sheeting salvaged from a construction site. Perhaps you can ask a local contractor or lumber yard to donate some of the materials that you will need.

MATERIALS LIST

1. 2 rolls of 4 mil polyethylene sheet, 12' x 25'
2. 2 rolls of duct tape
3. 2" x 2"'s:

Number	Length
8	10'
5	12'
4	6'
2	3'

4. Approximately 125' of lath or other wood strips
5. 2 thermometers, -20°F - 180°F
6. Nails, screws
7. Door hinges

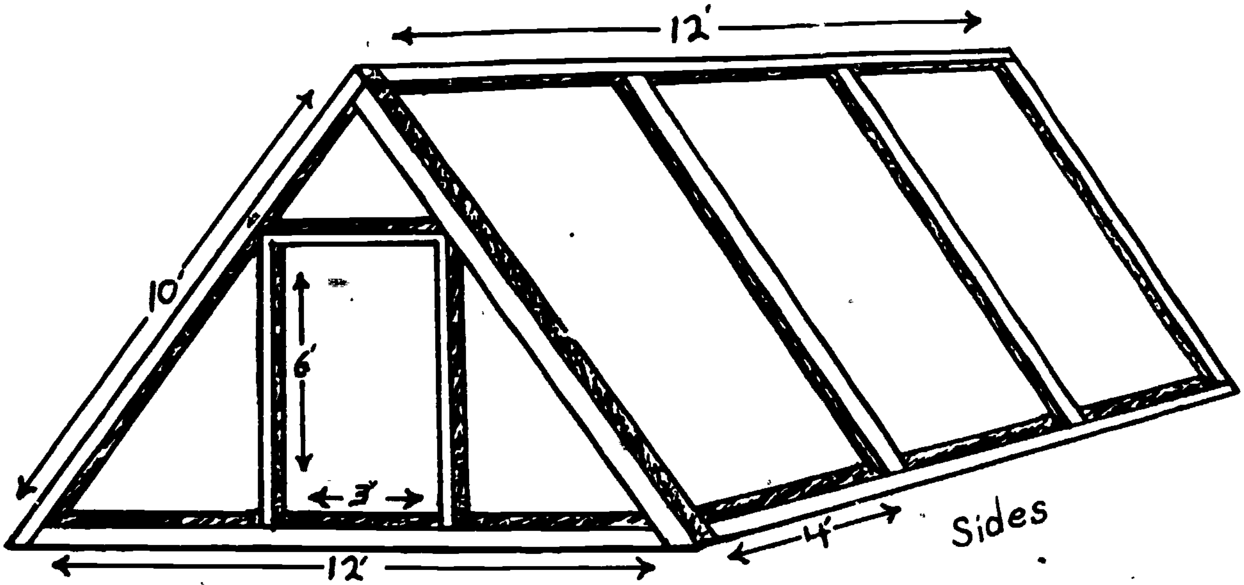


Figure 2. A Green/Ice (Fishing) House. Feel free to change the design to suit your needs and/or your salvaged materials!

Activities

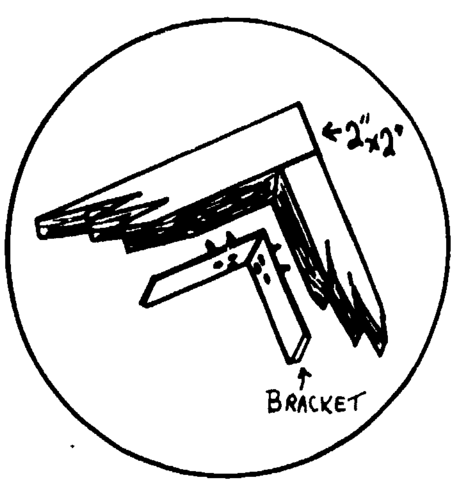
PROJECT CONSTRUCTION

1. Have students get all the materials together. Be sure that they know how 2" x 2" lumber is sold, and also how to figure the amount of plastic sheet they will need.

2. Cut 2" x 2"'s to the correct length.

3. To construct the frame, use right angle brackets. Bend them to fit each of the angles. The joining detail for a right angle may be seen in the following diagram.

Figure 3. Joining detail.



4. Spread the plastic sheeting over the frame. When your students have to join pieces together be sure that they have a 4" overlap. These overlaps are then taped with duct tape.

5. The plastic sheet is attached to the frame by strips of wood lath or old venetian blinds.

6. Design a hinged or removable door for the greenhouse.

AFTERWORDS - Questions to Ask

The following are some things students can do to better understand how their greenhouse works.

1. Turn the greenhouse so that the side, and then the front, of the greenhouse faces the sun. Allow 20 minutes or so for the greenhouse temperature to change. Record the temperatures inside and outside. What changes occurred? How do you explain them?

2. Record the temperature inside and outside on different days - clear, cloudy, overcast. Have students record their measurements.

	Clear	Cloudy	Overcast
INSIDE			
OUTSIDE			

3. Place a second sheet of plastic, foam rubber, canvas, or rock wool insulation on one side of the greenhouse. What temperature change does this cause in the greenhouse? Does this make the greenhouse retain heat?

4. What improvements or changes can you recommend in the construction of the greenhouse? What are some reasons for your recommendations?

5. What is the surface area of plastic your house exposes to the sun? If it was twice as large would it work better? Why or why not?

6. What would you have to do to change your greenhouse into a warm ice-fishing house? Why?

RESOURCES

Mother Earth News. 1974. Handbook of Homemade Power. Bantam Books, New York. ($2.50).

Prenis, John (Ed). 1975. Energy Book #1. Running Press, Philadelphia ($4.00).

Shurcliff, William. 1979. New Inventions in Low-Cost Solar Heating. Harrisville, New Hampshire ($12.00).

Strahler, Arthur N. 1963. The Earth Sciences. Harper and Row, New York.

EECP
Unit VI
Lesson D

LESSON TITLE: A Wet Solar Collector

LESSON OBJECTIVE

Students will build an active solar collector by using an air conditioner condenser and a heater/blower assembly from a wrecked car.

BACKGROUND INFORMATION - See Attached

ACTIVITIES - See Project Construction

RESOURCES - Resources are listed at end of lesson

A WET SOLAR COLLECTOR

BACKGROUND

An active solar collector absorbs the sun's rays and then heats either air or a liquid. The heated air, or liquid, then gives off its heat which can be used to heat one or more rooms of a house (Figure 1).

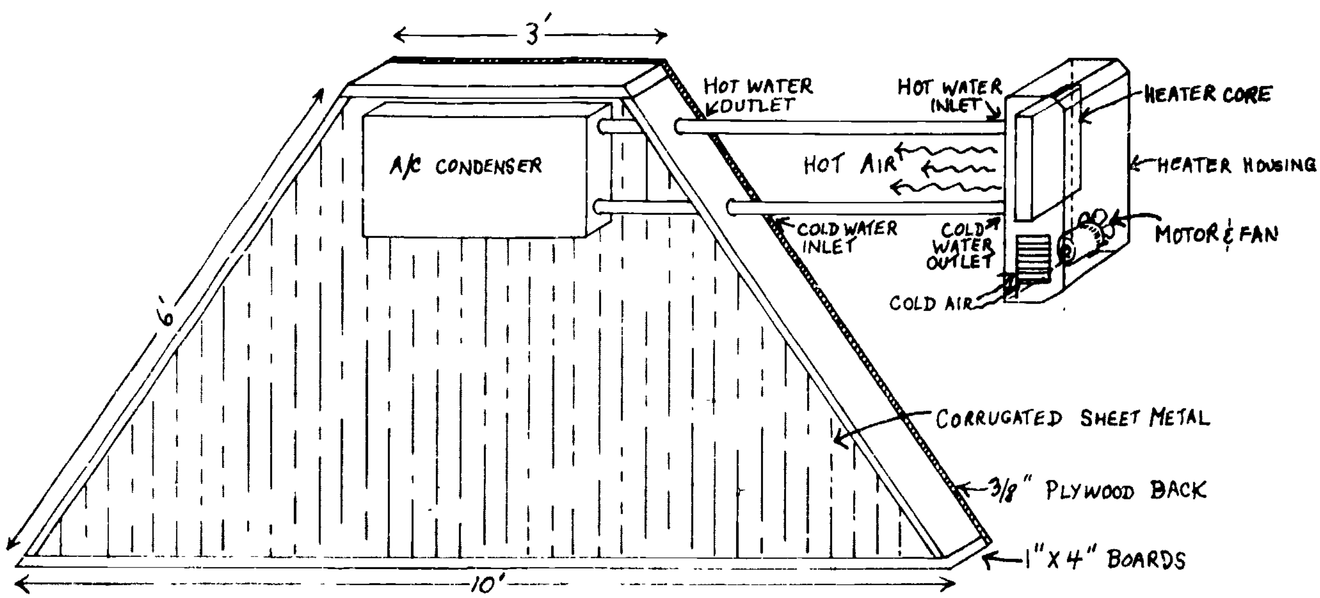


Figure 1. An active solar collector.

The collector works like this:

1. The corrugated sheet metal is warmed by the sun.

2. The sheet metal conducts its heat to the air in the collector.

3. The warm air flows around the air conditioner condenser. (This is called convection).

4. The warm air conducts its heat to the condenser - and the liquid in the condenser.

5. Now, the warm water rises. Why? (It weighs less!) It then flows out to the hot water inlet on the heater core. The heater core looks like a small radiator.

6. Cool liquid in the heater core flows over to the A/C condenser. This natural flow is called a thermosiphon. This was the only cooling system that the Model T Ford had!

7. This circulation process can be speeded up. By [illegible]ning on the fan motor, the heat from the liquid can be "forced" from the heater core. This now converts this passive solar collector to an active solar collector.

DESCRIPTION

LIST OF MATERIALS

1. SALVAGE FROM A CAR
   a. Heater assembly (core, housing, fan)
   b. Heater hoses and clamps
   c. Air conditioning condenser
   d. Battery, 12 volt
   e. Fan switch and wiring
   f. Anti-freeze

2. PURCHASE OR SALVAGE
   a. 4' x 8' 3/8" CDX plywood
   b. Nails - galvanized
   c. 25' of lath or wood strip
   d. One roll .4 mil plastic sheet, 12' x 25'
   e. 1" x 4", #3 pine or equivalent

Number	Length
2	6'
1	10'
1	3'

f. Corrugated sheet metal
g. Thermometer, $-20^{o}F$ to $180^{o}F$
h. Flat black enamel
i. Styrofoam or Blueboard; Rolled fiberglass insulation (metallic on one side; paper on the other)
j. Bolts

PROJECT CONSTRUCTION

The final design of a solar collector will depend on the make of air conditioning condenser, heater assembly, and other materials that you/your students can scrounge. Overall collector dimensions are found in Figure 1. Assembly details are found in Figure 2.

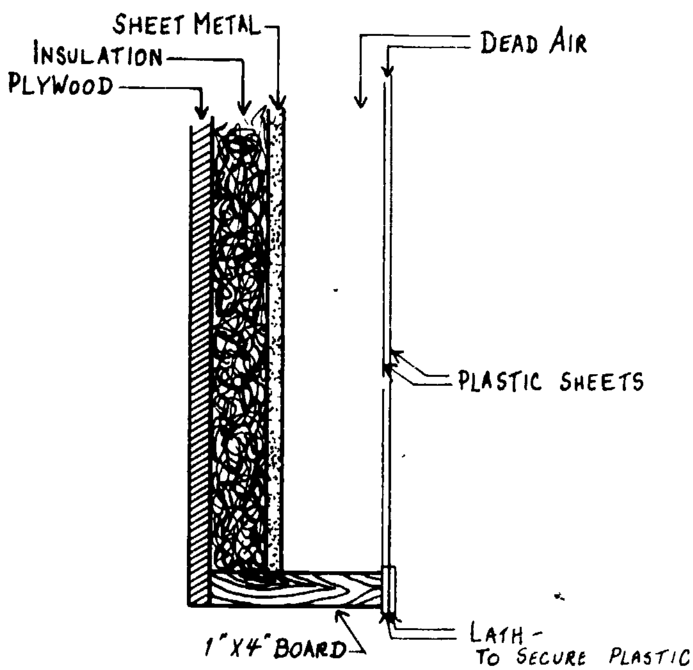


Figure 2. Assembly detail.

It is possible that the styrofoam/blueboard material touching the sheet metal will evaporate and condense on the plastic sheet. This possibility can be avoided by placing a layer of fiberglass insulation between the styrofoam and the sheet metal. The high temperature surface (metallic) should face the sheet metal side; the paper side should face the styrofoam insulation side.

(See Figure 2)

1. Locate a piece of corrugated sheet metal - pieces can often be found at a farm building construction site.

2. Nail the 1" x 4" boards to the top front surface of the plywood. Use galvanized nails.

3. Spray the interior of the collector - sheet metal and sides - with flat black enamel.

4. Mount the A/C condenser by drilling through the back of the condenser. Then use long ¼' bolts to mount the condenser securely to the corrugated sheet metal.

5. Use a forstner or spade bit to drill two holes through the side of the collector (for the hoses).

6. Mount the heater assembly on a wall, or bench.

7. Mix a 50/50 solution of water and anti-freeze. Use a gallon of each. Fill the condenser, hoses, and heater core with the solution.

8. Connect the condenser and heater core together with either automotive heater hose or garden hose. You may have to leave about a 2" stub of pressure line, and the fitting, on the condenser.

9. Clamp the hoses in place.

10. Wire the heater blower motor, including the switch and a twelve volt battery.

11. Nail a layer of four mil plastic sheet on the front of the collector.

12. Nail wood lath over the plastic, on the front edges of the 1" x 4" collector sides.

13. Place a second layer of plastic sheet over the first and nail down with more wood strips.

14. Now, face the collector toward the sun. Allow ½ hour or so for the liquid to warm.

AFTERWORDS - More Information/Questions

1. a. Turn the collector panel toward the sun and place the thermometer next to the heater core (fan off). Record this temperature and then record the temperature every minute up to 30 minutes. Record the temperatures, e.g.,

TIME 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TEMPERATURE															

TIME 17	18	19	20	21	22	23	24	25	26	27	28	29	30
TEMPERATURE													

b. Use the temperatures to graph the warmup curve of your collector.

c. Then, turn the fan on and record the temperature of the heater air every minute for 30 minutes. Does the temperature "level off"?

TIME 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TEMPERATURE															

TIME 17	18	19	20	21	22	23	24	25	26	27	28	29	30
TEMPERATURE													

2. Try the warmup measurements on a clear, cloudy, and an overcast day. What are the differences in temperature between the surrounding air temperature and heater temperature for these conditions?

3. Compare the collector at different fixed angles to the sun by tilting the panel. Allow 10 minutes for each position, and record the temperature readings. What is the best angle? Why?

TILT ANGLE	FLAT ON GROUND	60°	30°	90°
TEMPERATURE				

4. Make the measurements asked for in questions 1-3 at various times of the year and compare them.

5. What improvements would make this an even better solar collector? Why would these improve the collector?

RESOURCES

Baer, Steve. 1975. Sunspots: Collected Facts and Solar Fiction. Zomeworks Corporation, Albuquerque ($4.00).

Mother Earth News. 1974. Handbook of Homemade Power. Bantom Books, New York ($2.25).

Norton, Thomas W. 1977. Solar Energy Experiments for High School and College Students. Rodale Press, Emmaus, Pennsylvania.

Prenis, John (Ed). 1975. Energy Book #1. Running Press, Philadelphia, Pennsylvania ($4.00).

Shurcliff, William. 1979. New Inventions in Low-Cost Solar Heating. Brick House Publishing Company. Harrisville, New Hampshire.

Williams, J. Richard. 1974. Solar Energy: Technology and Applications. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan.

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LESSON TITLE: The Sunshine Papers

LESSON OBJECTIVE

Students will design and draw a flat plate solar collector. (The finished product will be the drawing. The finished drawing will include all dimensions, notes, list of materials, and other pertinent data needed in the construction of a solar collector.)

BACKGROUND INFORMATION - See Attached

ACTIVITIES

1. Students should read over the background information and study the drawings before drawing the flat plate solar collector.

2. Ask students in a construction class to critique the drawings. Could they build the collector as shown and described? What changes would students recommend before the plans are used? What emphasis would they like added?

RESOURCES - Resources are listed at end of lesson

THE SUNSHINE PAPERS

BACKGROUND

Basically, there are two types of solar collector systems - active and passive. Active systems require the use of a powered device to move the air or water from the collector plate to the structure being heated. Passive systems are designed to help the heated air or wate to move naturally from the collector to the structure being heated.

The following diagrams (Figures 1-8) will provide you with a range of various solar collector styles. The diagrams are found in the middle of this lesson.

1979

Trial Energy Materials

Minnesota Department of Education, Minnesota Energy Agency
Minnesota Environmental Education Board

DESCRIPTION

Assign students the task of completing a finished drawing of a flat solar collector. The illustrations which are used in the introduction to this activity as well as illustrations from magazines and books can be used to help students make decisions about what they want to draw.

THE DRAWING

1. An orthographic, three dimensional view with all frame dimensions and assembly details.

2. An isometric view with as much detail as possible.

3. A sectional view which shows internal assembly features and glazing positions.

THE SPECIFICATIONS

1. 1 x 6 pine for frame
2. #10 x 1½" wood screws for frame assembly
3. Absorber plate: Aluminum or copper roll bond plate coated with primer and two coats of flat black.
4. Glazing: .040 Kalwal Sunlite Premium 2, glued to frame.
5. Insulation: 1" fiberglass, or 1" urethane R-7.5.
6. Absorber plate, insulated from frame by high temperature nylon washers.
7. Backing: .020 aluminum sheet, rolled and crimped around the edge of frame.

THE ASSEMBLY INSTRUCTIONS

1. Collector frame: 5ft. x 3 ft. x 6".
2. Butt corners, connect with glue and flat head wood screws.
3. Glazing should be ½" lower than the top edge of the frame.
4. Absorber plate should be separated 1" from the glazing.
5. The collector should have 2" of air space.
6. Insulation fills remaining space.

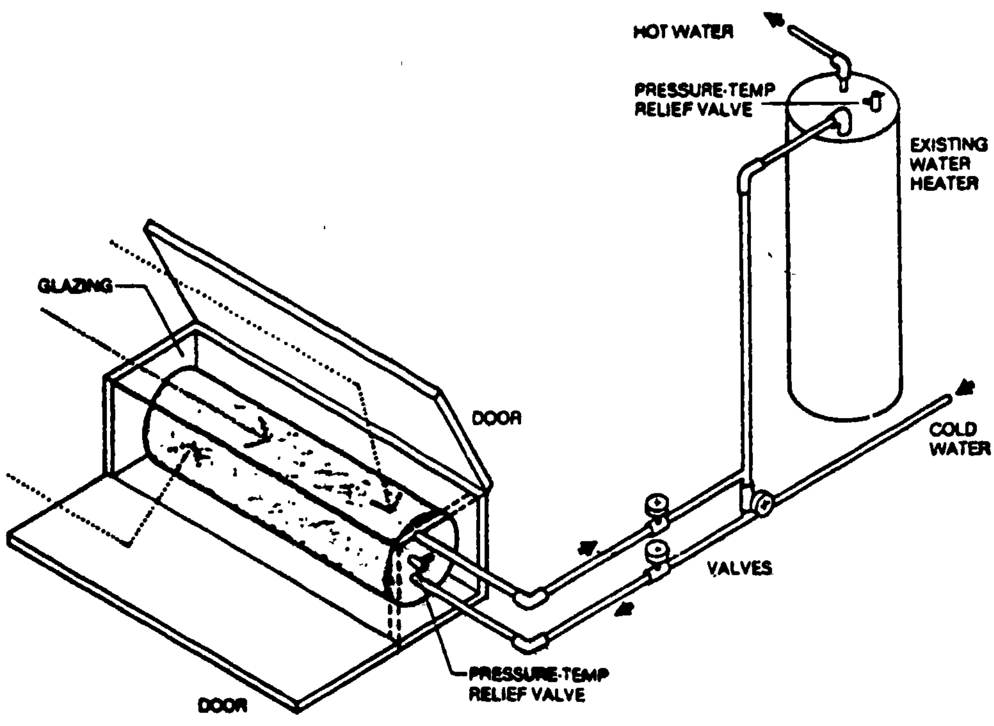


Figure 1. A "breadbox" water heater

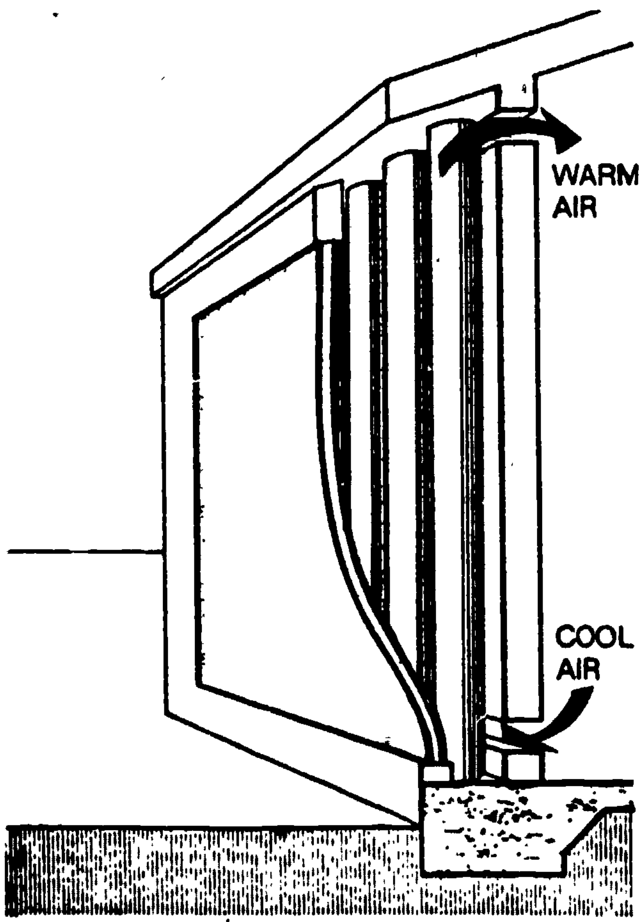


Figure 2. Tube Wall Solar Collector

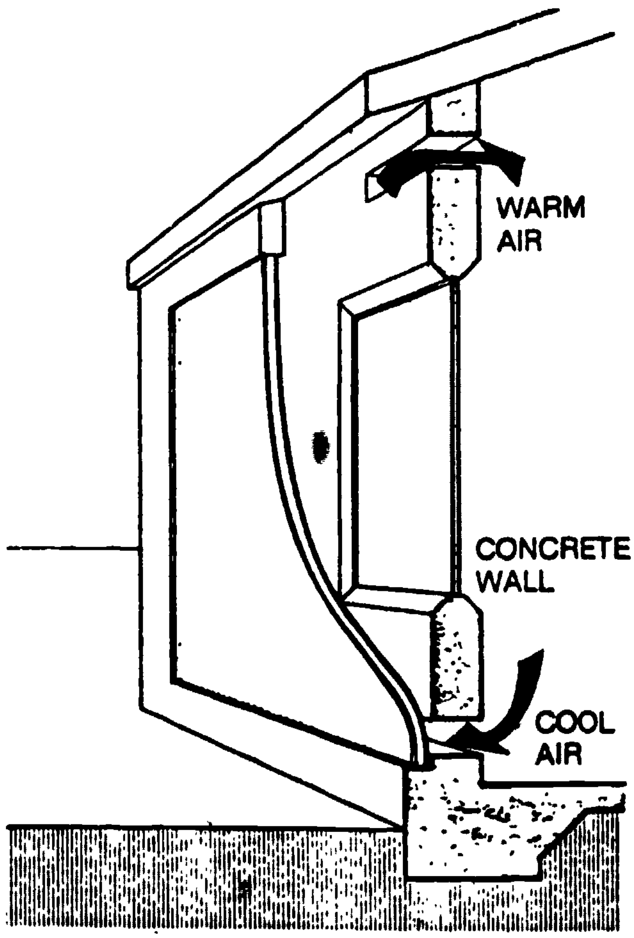


Figure 3. A trombe Wall, 4 to 6 between glazing.

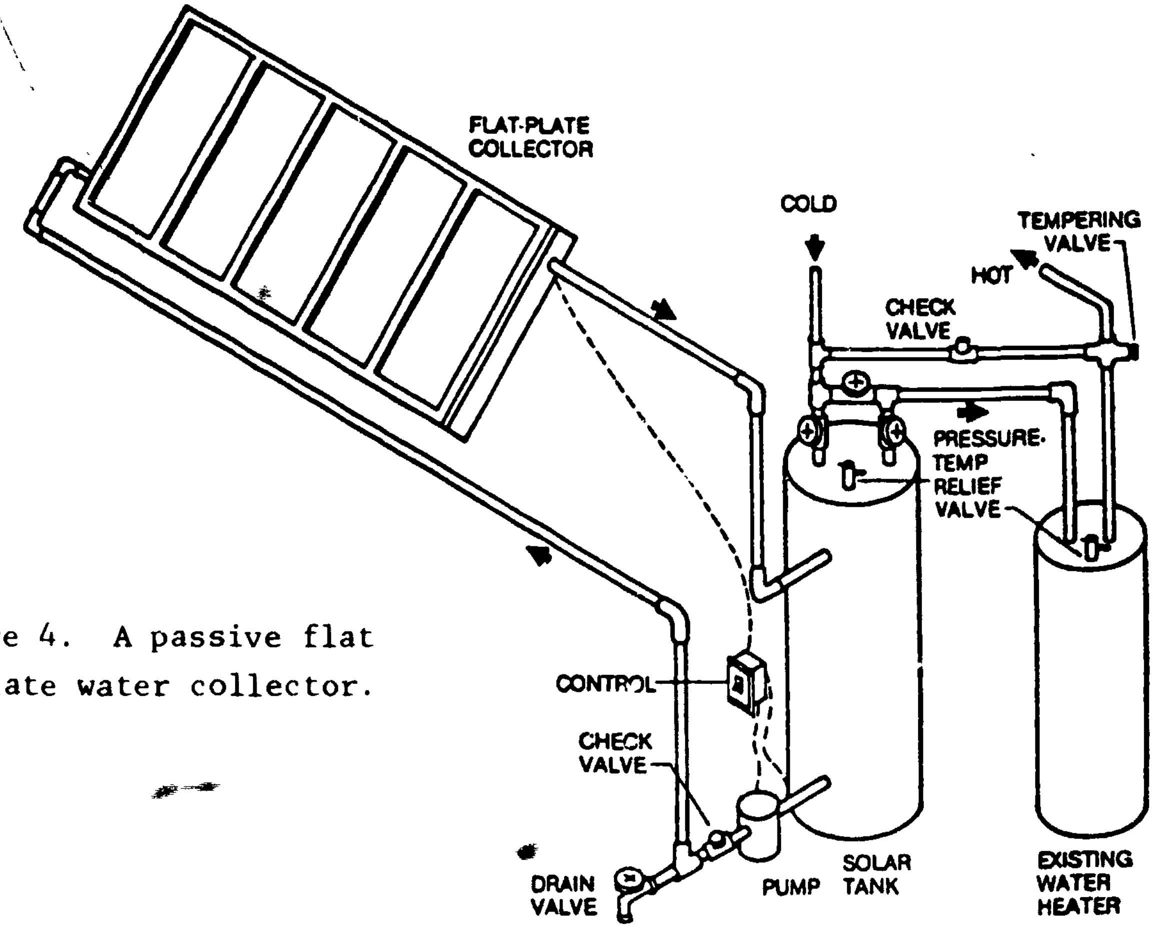


Figure 4. A passive flat plate water collector.

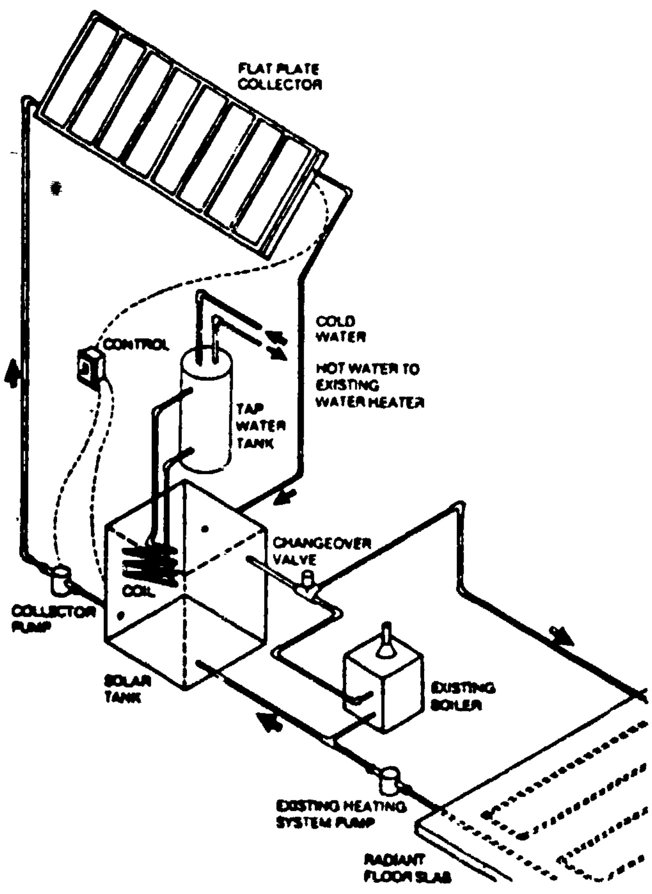


Figure 5. An active flat plate water collector.

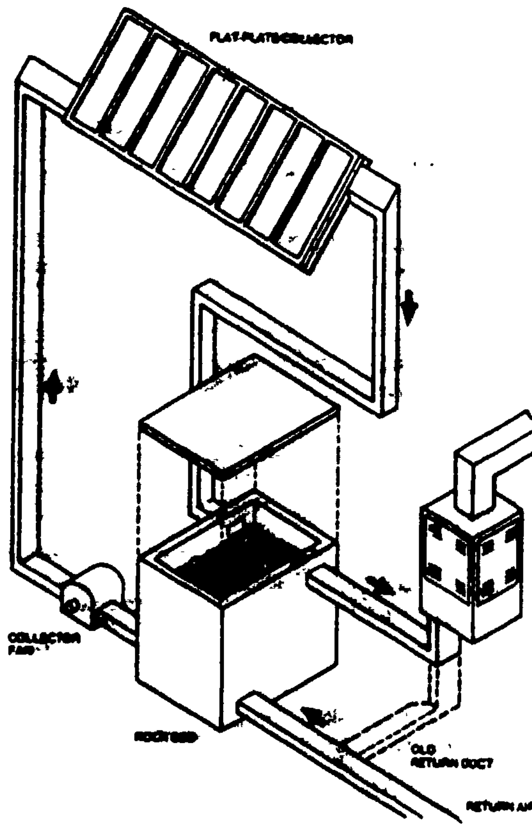


Figure 6. An active flat collector with rock bed storage.

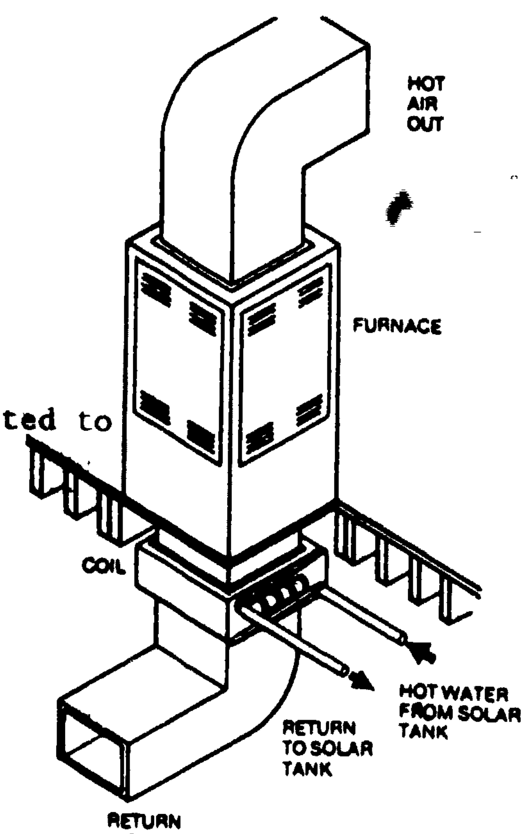


Figure 7. An active water collector connected to a forced air furnace.

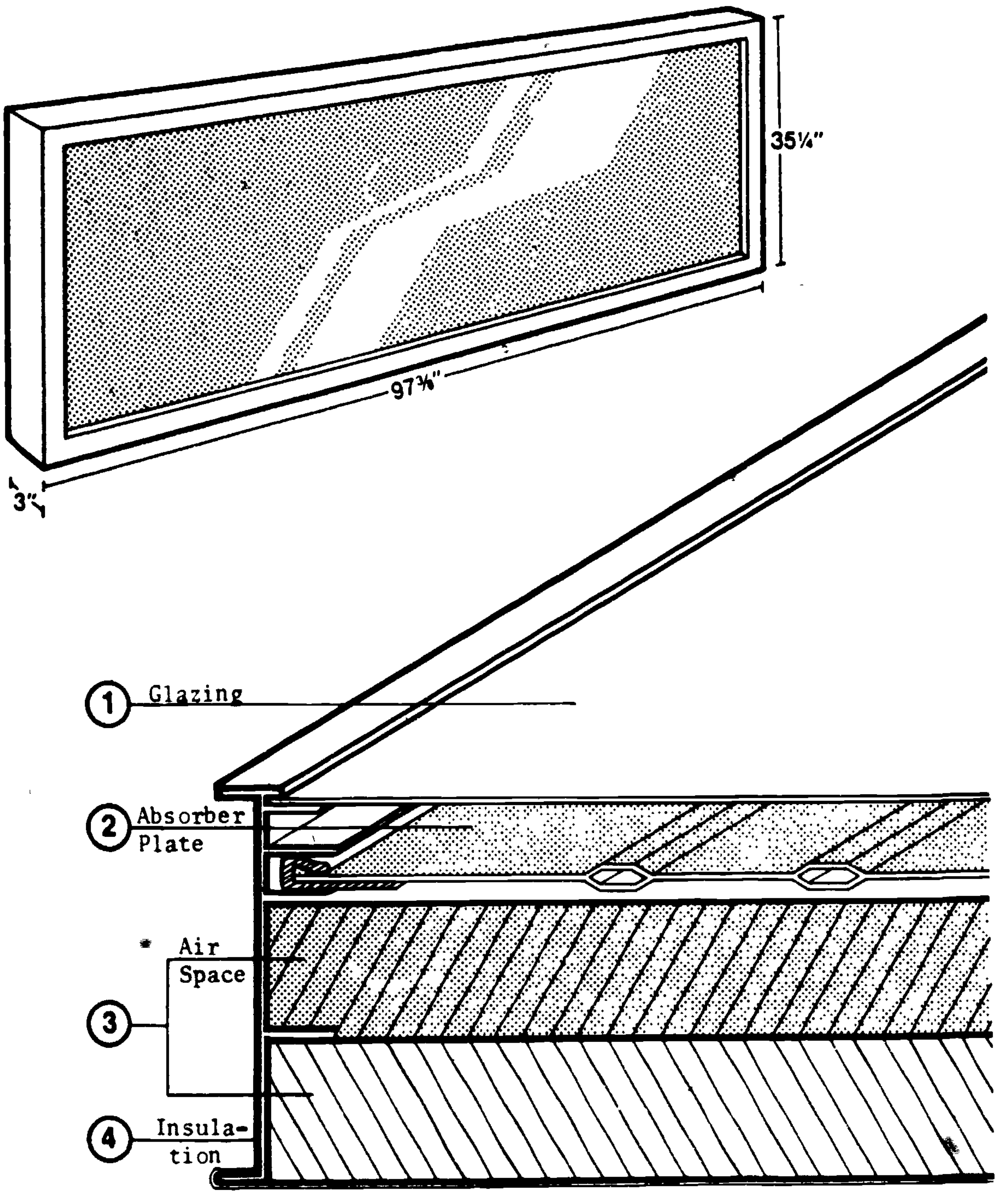


Figure 8. A simple flat plate collector.

AFTERWORDS - Questions to Ask

1. If students were to manufacture the item they have drawn, how would they price it?

2. What profit would they want?

3. What kind of guarantee would they provide the purchaser?

RESOURCES

Anderson, Bruce with Michael Riordan. 1976. The Solar Home Book: Heating, Cooling and Designing with the Sun. Cneshire Books, New Hampshire ($8.95).

Baer, Steve. 1975. Sunspots. Zomeworks Corporation, Albuquerque, Nex Mexico ($4.00)

Solar Heating, P.O. Box 1607, Rockville, MD 20850.

LESSON TITLE: Color Conduction Comparison

LESSON OBJECTIVE

Students will determine heat conduction characteristics of various colors and identify and use simple methods for measuring temperature differentials.

BACKGROUND INFORMATION

In order to increase energy efficiency, an individual can conduct simple and inexpensive experiments in dressing and the color of the clothing. The heat conduction characteristics of colors varies according to color and shade and can be measured by simple methods of measuring temperature differential.

ACTIVITIES - See Attached

RESOURCES

The Minnesota Trial Test Materials
Minnesota Department of Education
625 Capitol Square Building
St. Paul, Minnesota 55101

Developer of Minnesota Program
Mr. Tom Ryerson - Supervisor
Industrial Education

Color Conduction Comparison

EMPHASIS: Solar

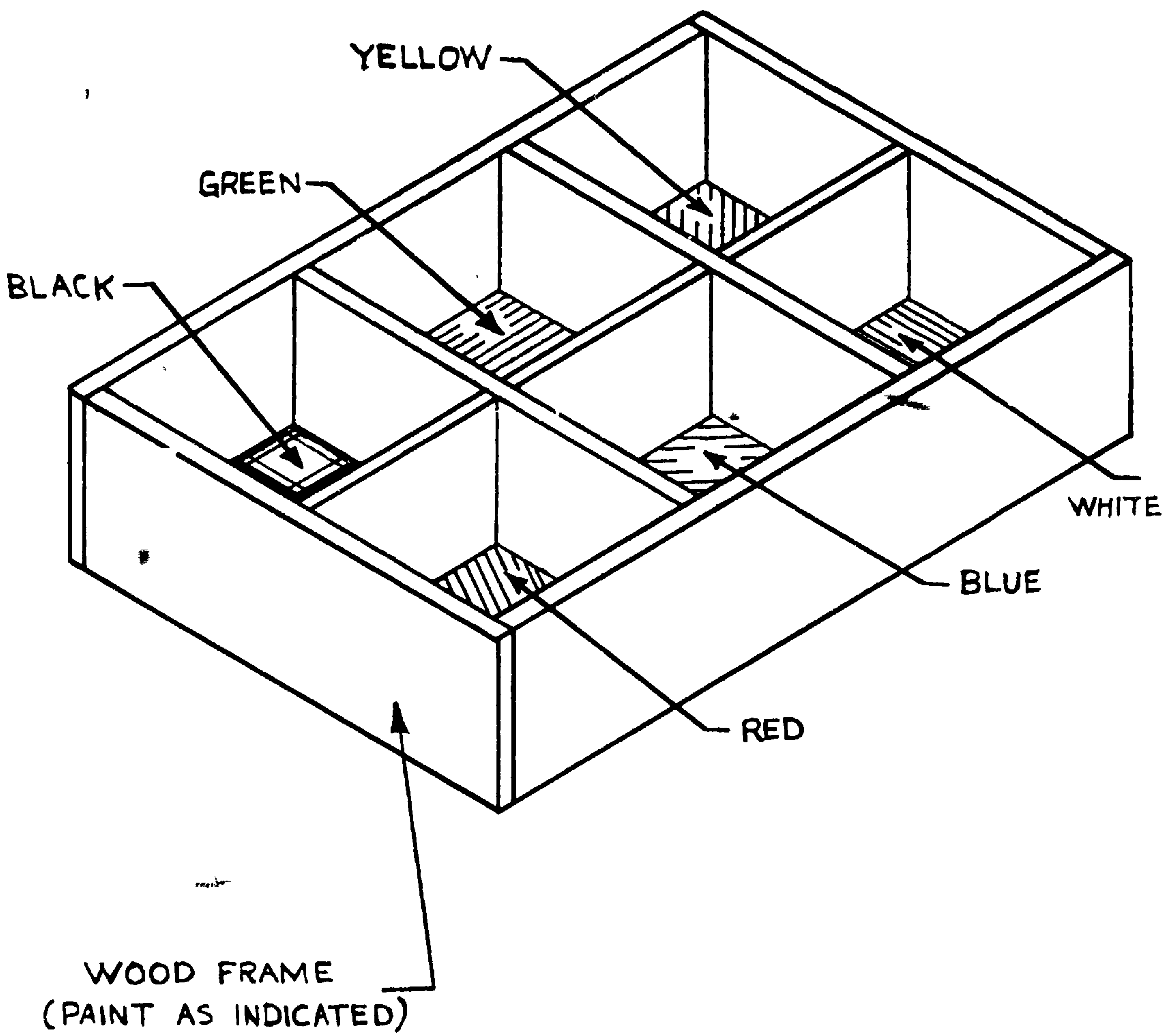
OBJECTIVES:

1. Determine heat conduction characteristics of various colors.
2. Identify and use simple methods of measuring temperature differentials.

ACTIVITY:

1. Build collection box as suggested in sketch.
2. Select colors in spectrum from black to white, or use colors suggested in sketch.
3. Place in sun. Use thermometers to measure temperature or use equally sized ice cubes to check melting rates.

NOTE: Test during different seasons and in different weather conditions.



NOTE:
SUN SHOULD BE EQUAL IN HEAT ON ALL PARTS OF BOX

LESSON TITLE: Wind Generator

LESSON OBJECTIVES

1. Student will construct a wind generator.

2. Describe measurable variables associated with the production of electricity from wind, such as:

   a. velocity
   b number of fan blades
   c. size of fan blades
   d. shape of fan blades

BACKGROUND INFORMATION

Along with solar energy there is yet another alternative, the wind. Just as wind was once used readily by farmers with the windmills, so it can be used today.

ACTIVITIES

1. Construct units with various blade design, number and size.

2. Test units in various wind conditions with a measurable electrical load.

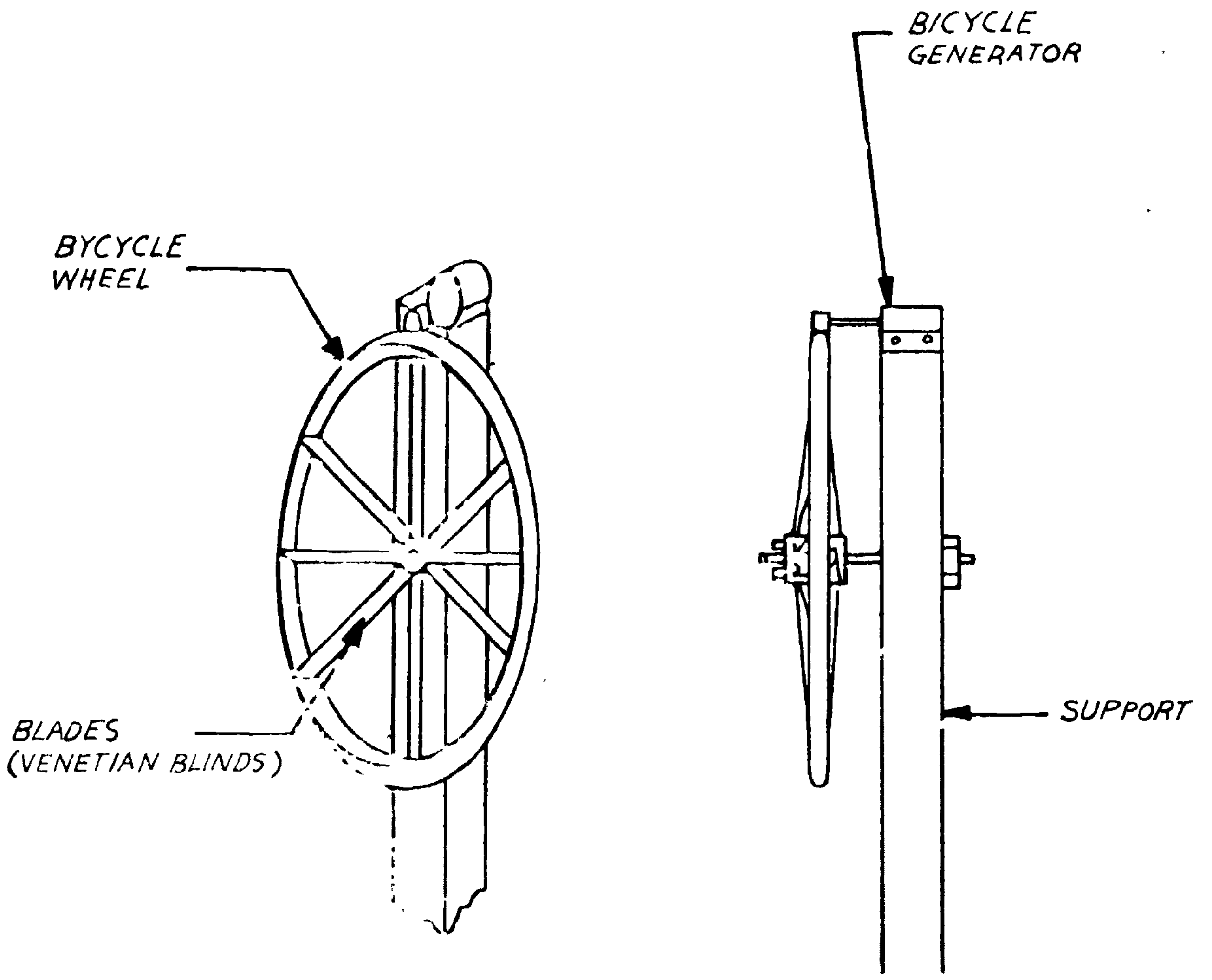
3. Be sure to see attached drawing.

NOTE: Let wheel build momentum before engaging generator. Add weight to wheel to increase flywheel effect for smoothing out gusts of wind.

RESOURCES

The Minnesota Trial Test Materials
Minnesota Department of Education
625 Capitol Square Building
St. Paul, Minnesota 55101

Developer of Minnesota Program
Mr. Tom Ryerson - Supervisor
Industrial Education


BYCYCLE
WHEEL
BLADES
(VENETIAN BLINDS)
BICYCLE
GENERATOR
SUPPORT

LESSON TITLE: Second Hand Solar Sources: Savonius Rotors

LESSON OBJECTIVE

Students will construct a vertical axis wind generator, a Savonius Rotor, from easily obtainable materials.

BACKGROUND INFORMATION - See Attached

ACTIVITIES - See Project Construction

RESOURCES - Resources are listed at end of lesson

SECOND HAND SOLAR SOURCES:

SAVONIUS ROTORS

BACKGROUND

Most of the wind generators being used today fall into one of two basic categories. They are the horizontal shaft or the vertical shaft type of wind generator. All of the large projects that have had substantial funding have been of the horizontal shaft type of wind generator. Other types of wind generators are also being considered which also have economic and technological advantages.

No matter what type of wind generator is used, approximately 60% of the energy in the wind can be extracted at its maximum efficiency. No wind machine can extract 100% of the energy in the wind. This is due to the dynamic characteristics of wind, design characteristics, the application for which the machine is used, and several related laws of physics. From this 60% blade inefficiencies and mechanical losses can substantially reduce the efficiency to lower than 35%. In their research for optimum designs which improve efficiency, wind engineers are constantly experimenting with new styles of vertical and horizontal wind generators.

One of the more popular wind generators to develop recently is the "vertical axis" wind system. Many configurations have been used although two new styles have emerged in the field. These styles are called 1) the Darrieus wind turbine, and 2) the Savonius Rotor.

The Darrieus wind turbine has air foil blades that are curved so that they can accept wind from any direction. This is contrasted to the horizontal axis wind generator, in which the machine must re-orient itself to each minor shift in wind direction. The Darrieus wind generator resembles the lower section of an egg beater. An electrical generator is connected, through gearing, to the vertical shaft which in turn provides the electrical output of the wind generator.

The second type of vertical axis generator called the Savonius Rotor is illustrated in Figure 1.

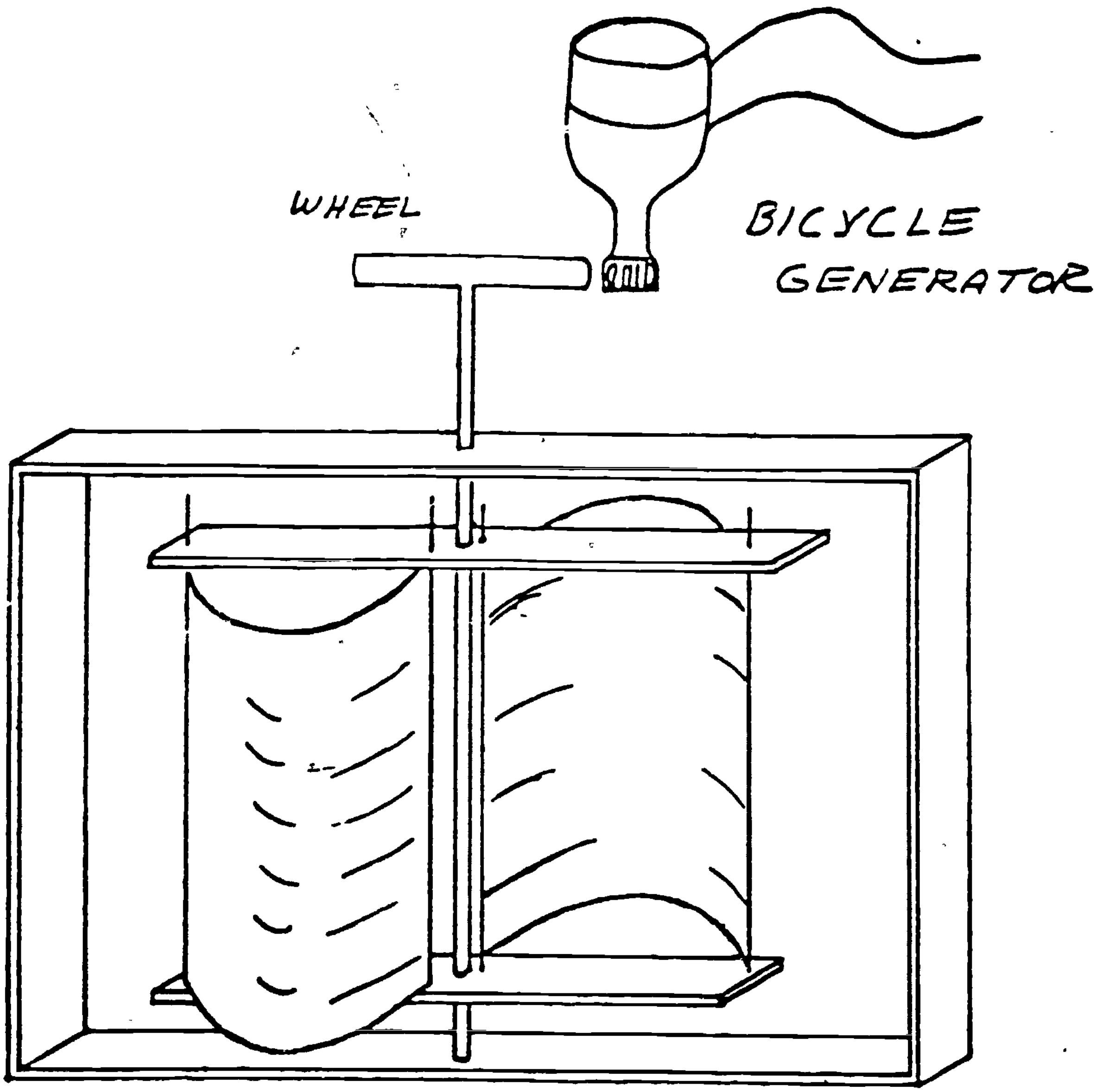


Figure 1. A Savonius Rotor

This illustration is a small classroom model built from ordinary materials. The output torque is controlled by adjustment of air flow. The design consists of a cylindrical shell, split in half and mounted to rotate between top and bottom plates. The two halves can be adjusted so that wind may flow between them. When the passage is closed as shown in Figure 2 circulation is impeded between the two blades, causing a low pressure to be developed on the back side of the upper blade. This causes a slowing down effect of the rotor. If the blades were adjusted as shown in Figure 3, then the area that was a vacuum, now has a pressure because of the wind passage through the blades. This causes the torque output to be increased by a factor of three or more. With this design the most efficient speed can be maintained.

The final assembly contains a lawn mower wheel attached to the power shaft. This wheel is then used to turn a simple bicycle generator, so measurements can be taken. Frictional losses can be reduced by adding grease to the rotating power shaft.

DESCRIPTION

MATERIALS LIST

Cans - coffee or 5 gallon or 46 oz. juice can, plastic or metal
Welding rods
Shaft material
Lawn mower wheel
Simple bicycle generator
Small house fan
Voltmeter
Tachometer - mechanical
Anemometer (borrow from physics department)

TEST PROCEDURES

1. Place the cylindrical halves in Position A.
2. Set wind generator in a constant wind source. Fans used in homes to circulate air can be used if the wind generator is small enough. If available, determine the input and output wind speed with an anemometer; record on Table 1.
3. Hook up the small generator and measure voltage output. Record on Table 1.
4. Measure RPM with a mechanical tachometer and record on Table 1.
5. Place the cylindrical halves in Position B and record the output voltage and RPM on Chart 1. Also record anemometer readings.
6. Place the cylindrical halves in Position C and record the output voltage and RPM on Chart 1. Also record anemometer readings.

TABLE 1

POSITION	VOLTAGE	RPM	ANEMOMETER READING INPUT	ANEMOMETER READING OUTPUT
A				
B				
C				

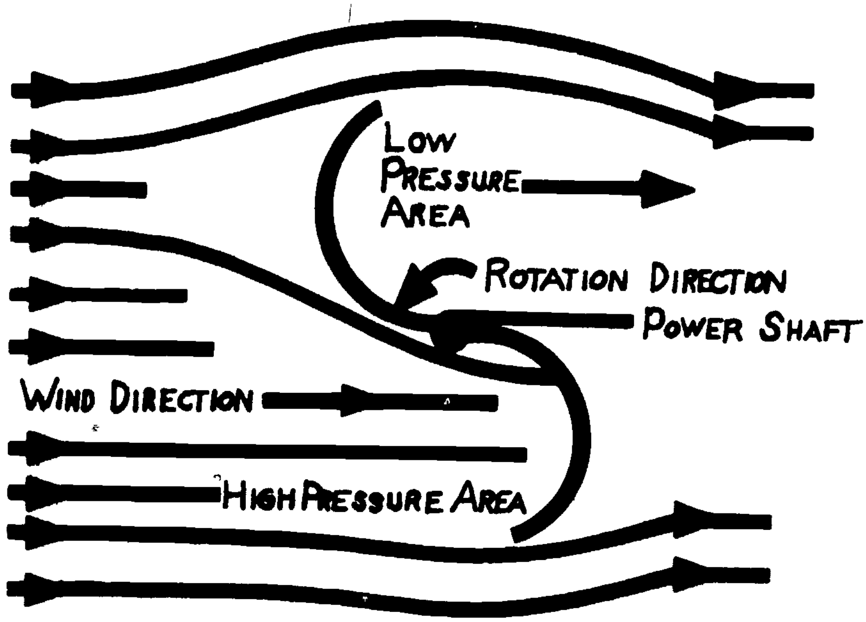


Figure 2. Influence of air flow on torque output: decrease rotor rate.

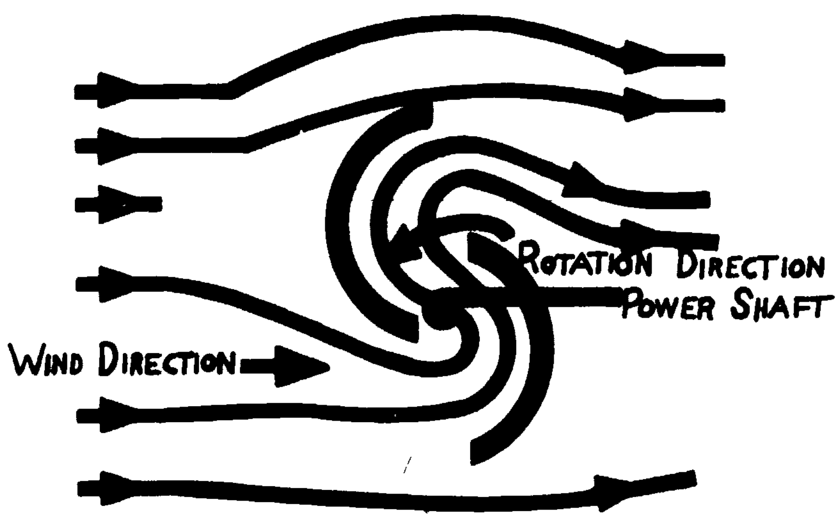


Figure 3. Influence of air flow on torque output: increase rotor rate.

Activities

PROJECT CONSTRUCTION

This project can be built from many parts already on hand. For example, any type of cylindrical container, plastic or metal, can be cut in half to make the blades. Welding rods should be attached on each side making a simple hinge so the rods can be removed when changing the blade position.

The upper and lower plates, made of wood, must be attached securely to the center power shaft. These plates should also have several holes drilled in them so the cylindrical shafts can take on one of three positions as illustrated in Figure 4.

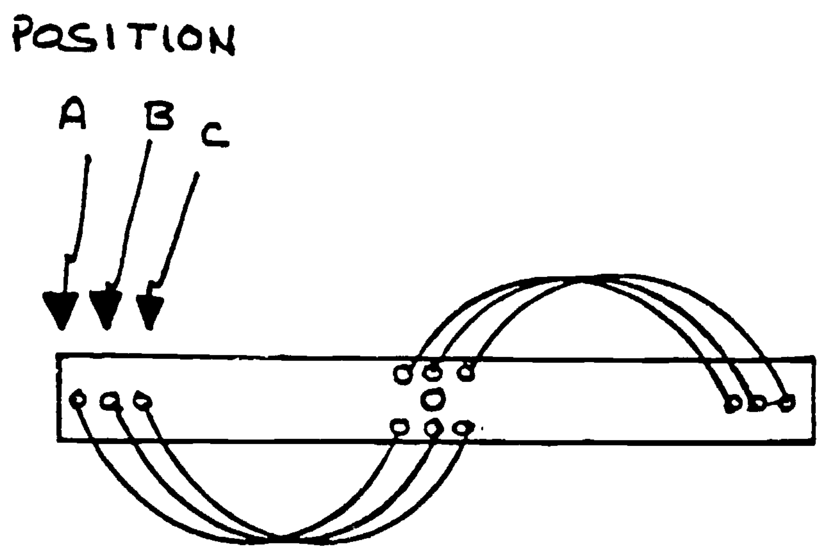


Figure 4. Positioning of cylindrical shafts.

Position A is the slow speed position, B is the intermediate position and C is the fastest position with the greatest torque.

The outer frame is simply used to support the entire rotor assembly (the plates and cylindrical halves). The height of the wind generator will be determined by the geographical location.

AFTERWORDS - Questions to Ask

1. Which position had the lowest speed and torque? Why?

2. Which position had the highest speed and torque? Why?

3. If an anemometer is used, is there a difference between input and output?

4. If yes, why is there a difference (in any position)?

RESOURCES

Hand, A. J. 1977. Home Energy How-To. Harper and Row, New York, New York ($9.95).

Kenney, Clarence. 1977. Wind Power for Home Heating. Popular Science. Times Mirror Magazines, Inc., 380 Madison Avenue, New York, New York, November.

McGuigan, Dermot. 1978. Harnessing the Wind for Home Energy. Garden Way Publishing, Charlotte, Vermont ($4.95).

Prenis, John (Ed). 1975. Energybook #1. Running Press, 38 South Nineteenth Street, Philadelphia, PA 19103 ($4.00 plus $0.25 postage).

Shepard, M. L. and others. 1978. Introduction to Energy Technology. Ann Arbor Science Publishers, Inc., P.O. Box 1425, Ann Arbor, MI ($16.50; Paper - $10.95).

Unit VI

Lessons I-K (Coal)

Note: Coal is one of Indiana's most abundant resources. This portion of the lessons for Unit VI has been designed to aid students in becoming more knowledgeable about coal as a fossil fuel and nonrenewable resource. A wide variety of charts, graphs, motivational ideas and lessons are provided.

EECP
Unit VI
Lesson I

LESSON TITLE: Coal and Energy

LESSON OBJECTIVE

The objectives of this lesson are:

1. The student will develop an understanding of how coal is made.
2. The student will know the major uses of coal.

BACKGROUND INFORMATION

The background information for the coal lessons is a "working informative" section. Information is provided including probing questions dealing with the material. It is suggested that the reader study the background information first, and then go back and answer the questions. This same method may be applied to students. Also some of the maps and charts may be used as dittos. (See attached for more background information)

ACTIVITIES

1. Discuss with students how coal is formed.
2. Bring samples of coal to class and have students use a hand lens to observe texture, content etc. Discuss what they observed.
3. Have students design an experiment to test energy potential in coal.
4. Discuss the energy potential test results and select several for demonstration in or out of classroom.
5. Select a test which involves burning coal and use these questions during and after demonstration:

    a. Is there energy in coal?
    b. How do we know this?
    c. How did the energy get there?
    d. As the development of coal is traced back to its origin, what source are we actually releasing today. (Solar)
    e. Invite a resource specialist from a public service utility or coal mining operation to the classroom.

6. More Activities - How Coal is Formed (See Attached)

RESOURCES

Coal Minicourse, National Science Foundation, Pre-college Teacher Development in Science Program The Geosciences Today, Purdue University, Department of Geosciences, West Lafayette, Indiana, 47907.

Indiana Bureau of Mines and Mining
125 South 15th Street
Terre Haute, Indiana 47807

Indiana Department of Natural Resources
Geological Survey
611 North Walnut Grove
Bloomington, Indiana 47405

Background Information

Coal is often called buried sunshine. Do you know why?

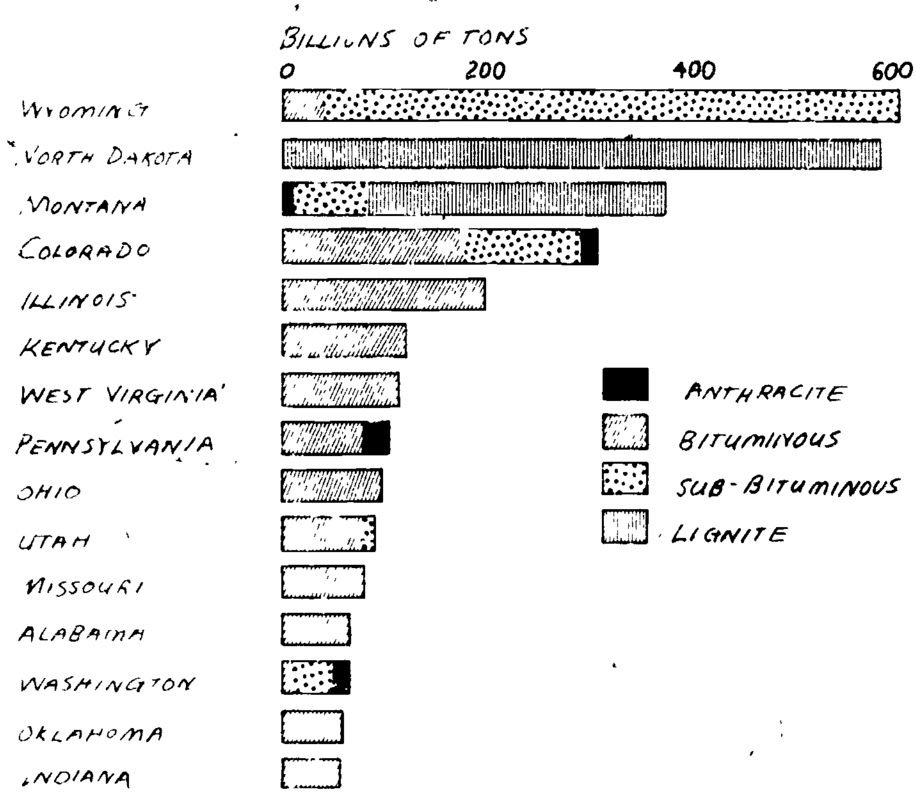
When we burn coal, we use sunlight that reached the earth millions of years ago. The energy in coal is nothing but the energy of sunshine, captured and buried in the ground long ago. Most of the coal was made about 300 million years ago when the earth was much warmer and more moist. Lush giant ferns and palm trees grew in vast forests and swamps. As these plants died and decayed, a thick layer of plant material was gradually built up and as time went on, a layer of peat was formed from the rotting stems and leaves. This layer was later covered by sand from a river, or by wind-blown dust until it was buried deep in the ground. Under the pressure of the soil above it, the peat slowly changed into coal. Still locked in it was the chemical energy that plants had stored. Today this buried sunshine, which came from the sun millions of years ago, is released as energy when coal is burned.

Types of Coal

After layers of dead plants had been buried thousands of years, they became layers of peat. Peat looks like dried wood and is found in swamps. When dried, peat will burn and give heat, but is very smokey. Some of the spongy layers of peat were pressed down into thinner layers of lignite, a low-grade coal. The load of sediments grew, pressure increased, and the lignite turned into soft (bituminous) coal. Bituminous coal is harder than lignite, but is called soft coal because it can be broken easily into the right sizes for many uses. Coal which is not quite as hard as bituminous is subbituminous. In some places, coal beds were involved in folding and uplift that produced mountain ranges. During the process, the soft coal turned into hard (anthracite) coal. What type do you think we have in Indiana? Why?

Figure 1 is the chart of the different types of coal mined in the U.S. Anthracite makes up only a small percentage of the world's supply of coal. The rest is the softer coal, bituminous, which is the most important and most plentiful type.

Figure 1. Types of Coal Mined in the U.S.



Questions for Figure 1:

Which type of coal is mined in Indiana? ____________________

Which type is mined the most in the U.S.? ____________________

Which type is mined the least? ____________________

Where Coal is Found

See Figure 2.

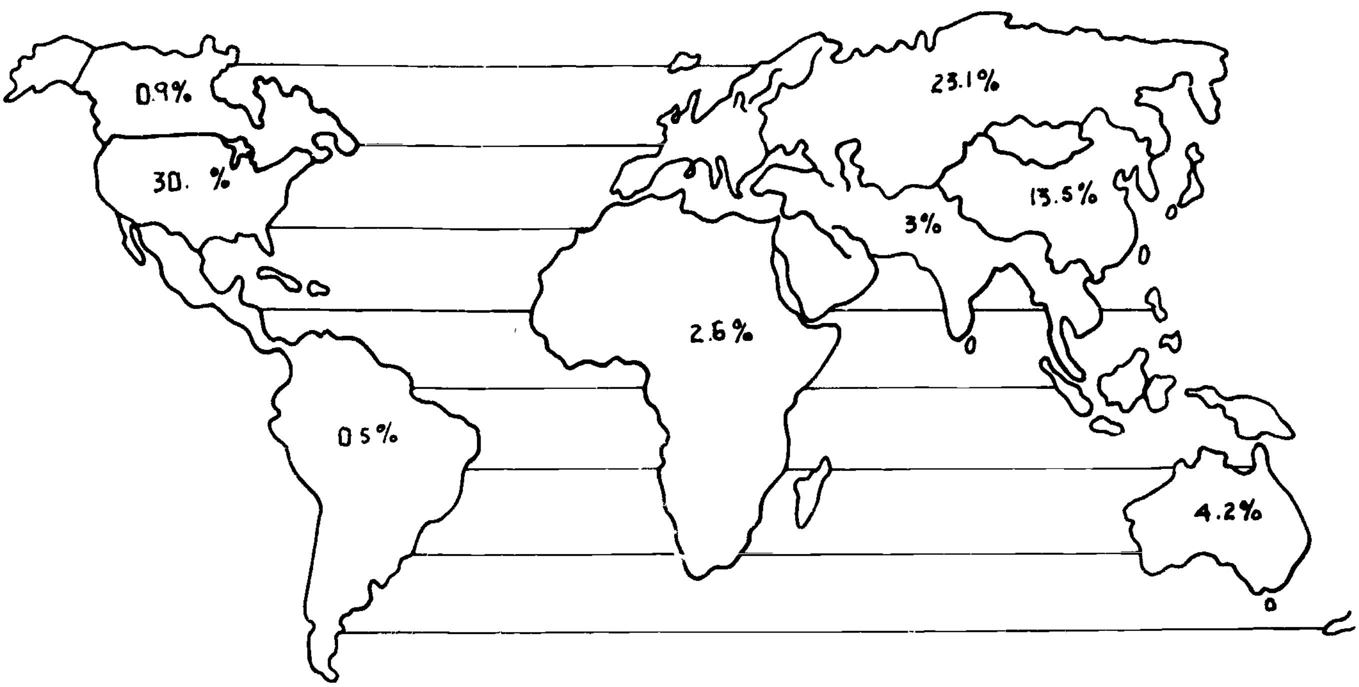
What country holds most of the coal reserves? ____________________

____

What country holds the least? ____________________

____

Figure 2. Recoverable Coal Reserves of the World



CANADA 0.9% UNITED STATES 30.8% LATIN AMERICA 0.5%
EUROPE 21.3% AFRICA 26% USSR 23.1% CHINA 13.5%
REST OF ASIA 3% OCEANIA 4.2%

Figure 3 shows the coal areas in the United States.

1. Which state holds most of our coal reserves? ______________________

____

2. Why do you think that coal deposits are in these areas? __________

____

Figure 3. Coal Areas in the United States

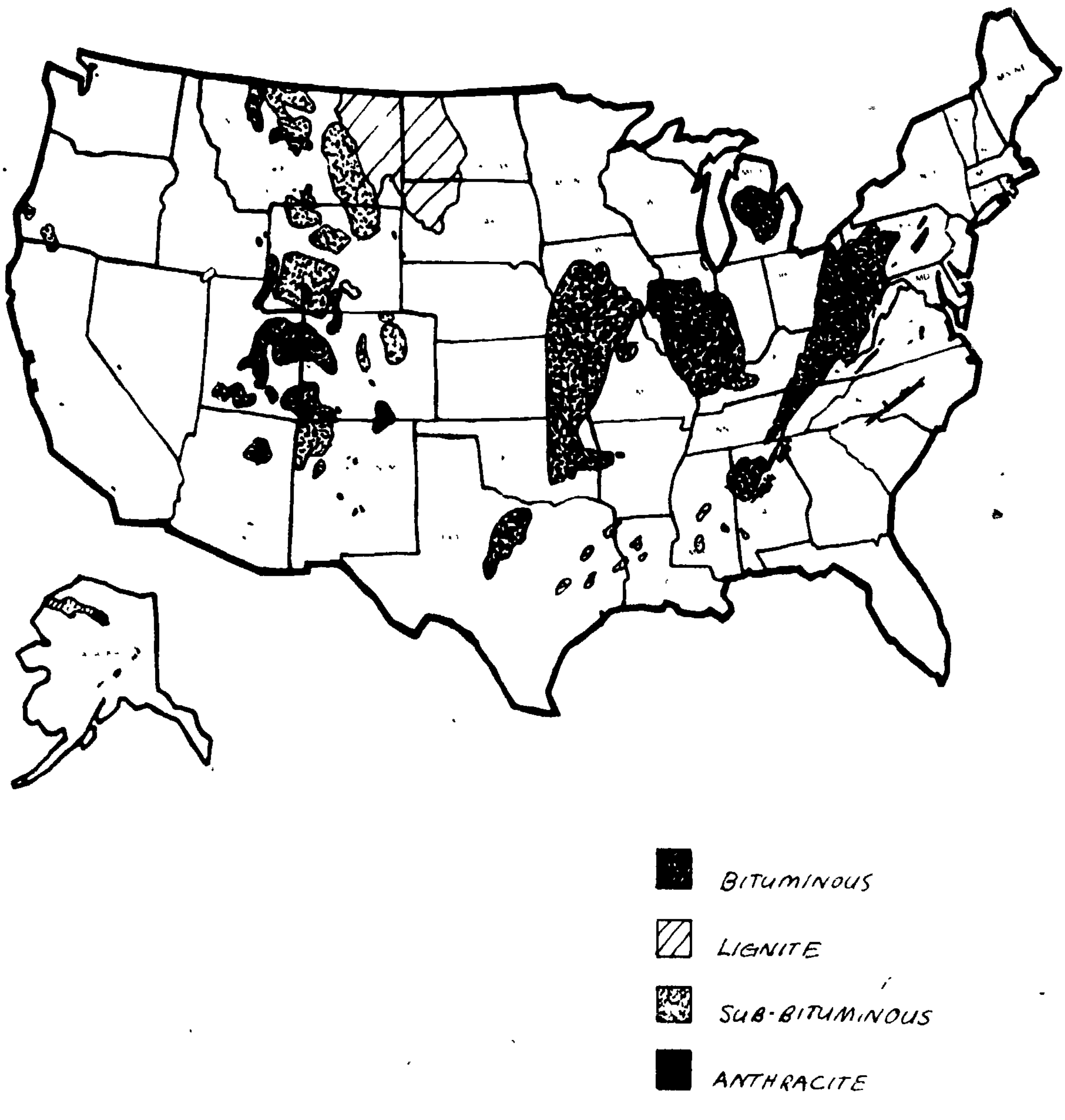


Figure 4 shows a map of the places in Indiana where coal can be found.

1. Why do you think that coal deposits are only found in certain parts of Indiana?____________________________________

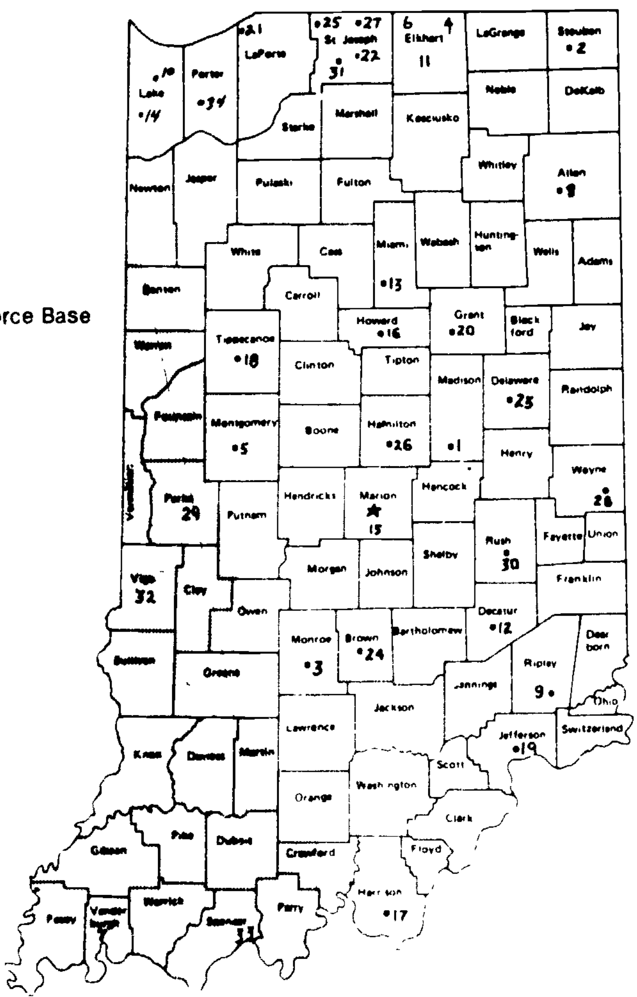
____

2. Why isn't coal found in Lafayette?____________________________________

____

Figure 4. Places in Indiana Where Coal Can be Found

1. Anderson
2. Angola
3. Bloomington
4. Bristol
5. Crawfordsville
6. Elkhart
7. Evansville
8. Fort Wayne
9. Friendship
10. Gary
11. Goshen
12. Greensburg
13. Grissom Air Force Base
14. Hammond
15. Indianapolis
16. Kokomo
17. Laconia

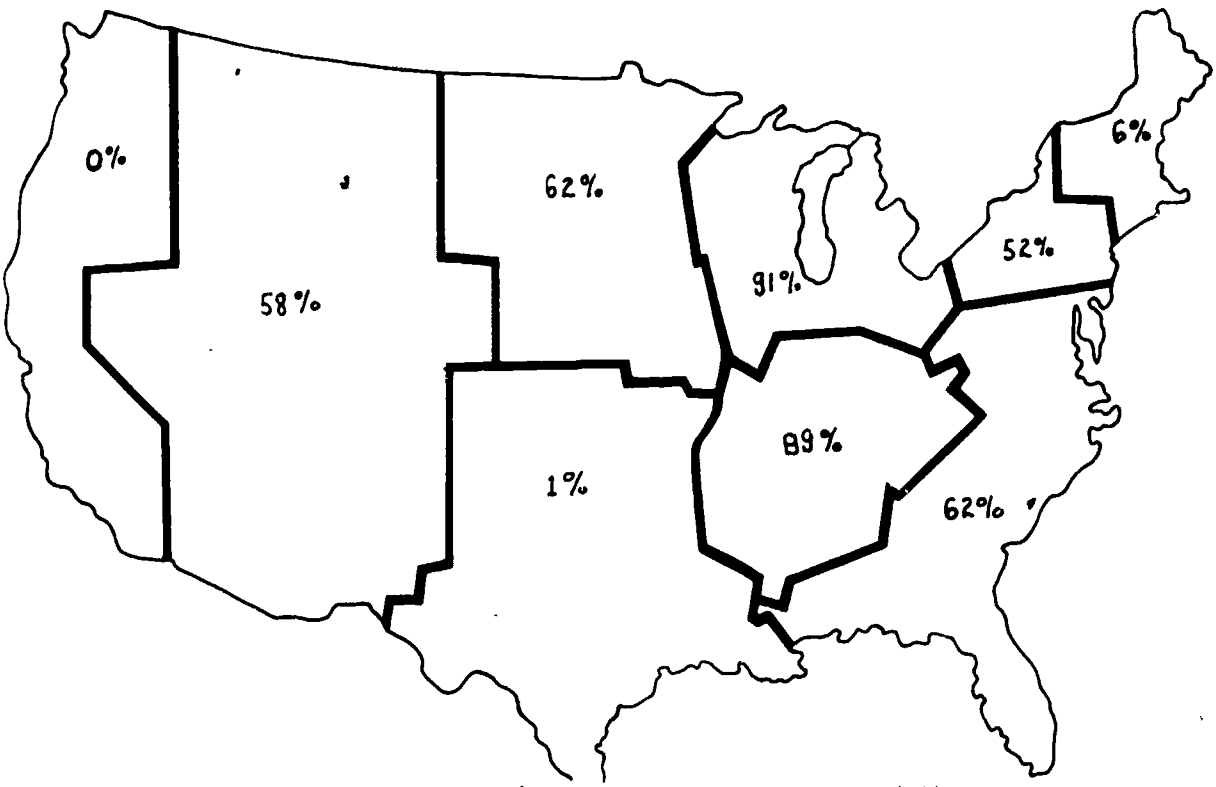


18. Lafayette — West Lafayette
19. Madison
20. Marion
21. Michigan City
22. Mishawaka
23. Muncie
24. Nashville
25. New Carlisle
26. Noblesville
27. Notre Dame
28. Richmond
29. Rockville
30. Rushville
31. South Bend
32. Terre Haute
33. Troy
34. Valparaiso

The reason why these places have the most coal deposits can be found by looking back 300 million years to the time when most of the coal was made. Do you remember how coal was formed? The places where the coal reserves are now used to be very warm with lots of plants and trees. More coal was formed here because of the climate, the swamps, and the forests.

Uses of Coal

Figure 5. Percentage of Coal Used as Fuel in the U.S.



0% PACIFIC
91% EAST NORTH CENTRAL
1% WEST SOUTH CENTRAL
58% MOUNTAIN
52% MIDDLE ATLANTIC
89% EAST SOUTH CENTRAL
62% WEST NORTH CENTRAL
6% NEW ENGLAND
62% SOUTH ATLANTIC

Above is a chart of the % of coal used as fuel in the U.S.

Which areas use coal as fuel the most? ____________________

Which areas use coal as fuel the least? ____________________

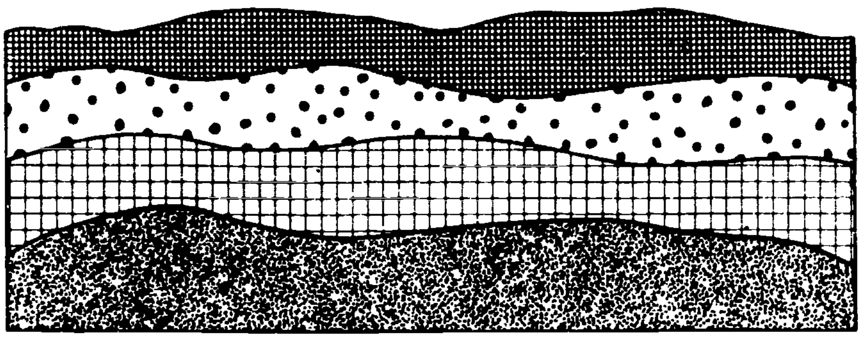
Why do you suppose these areas do not use as much coal as the Midwest? ____________________

____

These areas: the Pacific, West South Central, and New England, use other resources such as oil and gas other than coal for their chief fuel because of their location. What other types of energy might they use? ____________________

Activities

Figure 6. How Coal is Formed



Set up own model like the above of how coal is formed.

Material:

1 aquarium
coal (use charcoal as substitute, but charcoal is compressed wood - not the same as coal)
peat (can be bought in store)
plant material (plants, stems, roots)
soil

Place a layer of coal in the bottom of the acquarium for the first layer, then put a layer of peat on top of the coal. Next, place the plant material on top of the peat, and last, cover it with soil. We now have our own model of how coal is formed! Now that you have made the model, can you think of a way to get the coal out without disturbing the peat, plant material, or soil?

-Make a large tree of "uses of coal." Draw pictures of uses or cut out magazine pictures to illustrate.

We use coal to make cement. What do we make with cement?

____

What else do we make from coal? ______________________________

____

More than 200,000 different products are made from coal. We also use coal to make products such as rubber and man-made fibers, drugs, and perfumes, food flavoring and dyes, and plastics and waterproofing materials. Fill in the blanks of the tree of coal uses in Figure 7.

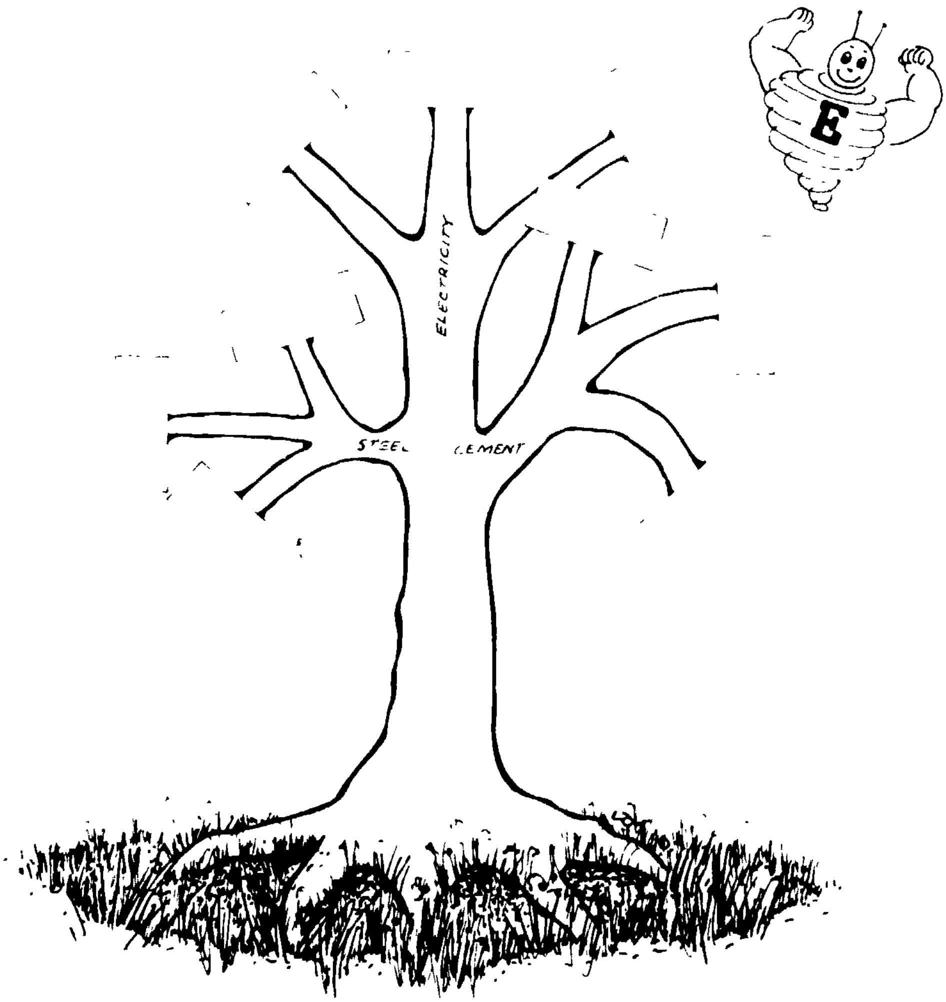


Figure 7. Uses of Coal

We use coal in other ways, although we use most to make electricity. Name different ways we use electricity?

____

____

Here are some examples of the amount of coal used each year for operation of a variety of appliances.

<u>Electric Water Heater</u>
2 tons of coal for a family of four.
<u>Range</u>
A half-ton of coal for a family of four.
<u>Clothes dryer</u>
A half-ton of coal
<u>Color TV</u>
A half-ton of coal

It takes about one ton of coal to produce 2000 KWH. Checking the number of KWH used during a billing period will show a consumer how many pounds of coal were used to meet the consumer needs.

One big use of coal is in making steel. Can you think of different items of steel?

Essentially all coal now being mined in Indiana is consumed as fuel. It is used for heating homes and public buildings, and for manufacturing ceramics.

Coal in Indiana has too much sulfur content to make <u>coke</u>.

Do you suppose that all of our coal stays in Indiana? ________________

About 5 million tons each year is shipped to Illinois, Wisconsin, Michigan, Minnesota, Iowa, Kentucky, Tennessee, Georgia, and Florida. However, 22 million tons is shipped into Indiana from Illinois, Kentucky, Ohio, West Virginia, Pennsylvania, and Montana.

Why don't we just use our own coal? ______________________________

____

We use coal outside of our own because we need coking coal.

Indiana ranks 7th among 25 states in annual coal production. 13 of the states have higher coal reserves. There is great competition in the Midwest market.

LESSON TITLE: Types of Mining and Mines

LESSON OBJECTIVE

1. The student will develop an understanding of various types of mining methods.

2. The student will be able to explain how problems associated with the mining and burning of coal can be reduced.

BACKGROUND INFORMATION - See Attached

ACTIVITIES - See Attached

RESOURCES

Coal Minicourse, National Science Foundation, Pre-college Teacher Development in Science Program The Geosciences Today, Purdue University, Department of Geosciences, West Lafayette, Indiana, 47907.

Indiana Bureau of Mines and Mining
125 South 15th Street
Terre Haute, Indiana 47807

Indiana Department of Natural Resources
Geological Survey
611 North Walnut Grove
Bloomington, Indiana 47405

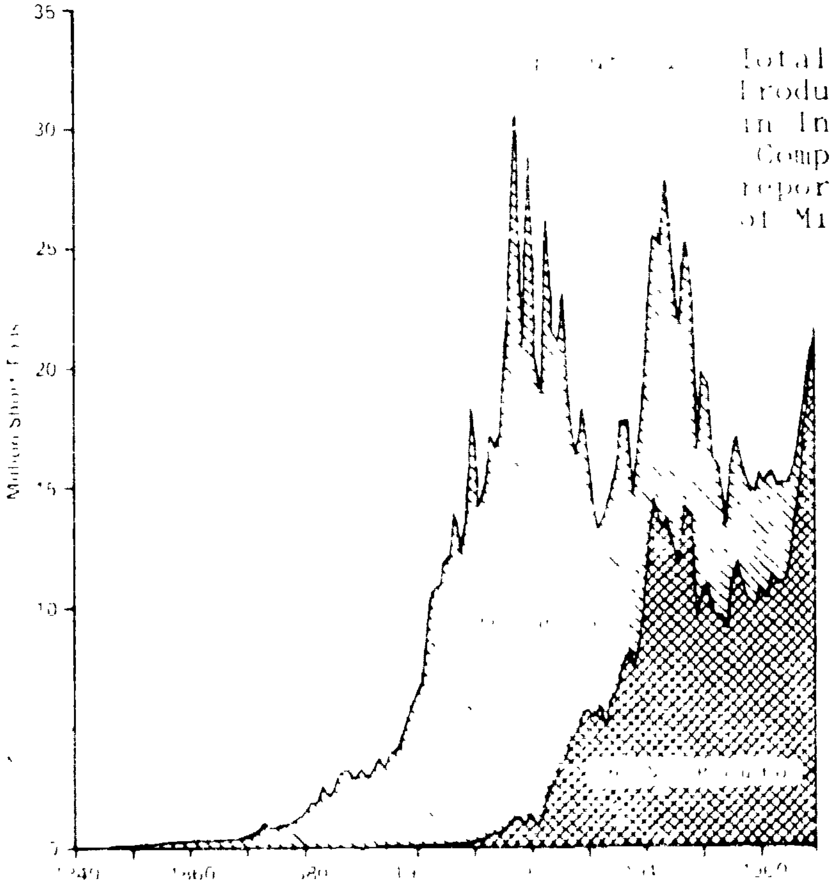
Background Information:

Mining Methods

One easy way to get the "buried treasure" is through a simple process of stripping off the layers to reach the coal that lies nearer to the surface. Each layer is placed in a different pile so that they won't mix together. This is called strip mining or surface mining. Giant power shovels and other earth-moving equipment is used to dig a long trench to get to the coal seam. The "dragline" is the most essential piece of equipment used. It affords access to the underlying coal reserves. Operating continuously, it only shuts down on Christmas.

AMAX coal company's Chinook mine in Clay County annually strips away the overburden from about 150 acres. When the coal is exposed, it is usually broken up by explosives. It takes three 18 hour shifts for the dragline to uncover enough coal to keep the coal loading shovels busy for about one shift. These shovels load the raw coal into specially-built, diesel haulage trucks. The trucks carry the 100-ton loads up to 5 miles to the preparation plant where the coal is readied for delivery. The preparation plant can process up to 900 tons of coal per hour. The coal is carried by conveyers where it is broken up in no larger than 5 inch pieces, cleaned, crushed, stored, and readied for delivery by rail. Seventy-three percent of Indiana coal is transported by rail, the remainder mainly by truck.

In Indiana, strip mining accounts for 60% of the annual production.



Total Coal Production and Production by Strip Mines in Indiana, 1840-1971 (Compiled from annual reports of the U.S. Bureau of Mines)

Activities:

Why is strip mining the method used? ____________________

____

What do you predict for the future (e.g. year 2000)? ____________________

____

How does the graph look now? ____________________

____

Currently strip mining is the most efficient method in Indiana. Coal has been mined in 21 counties in Indiana, but most of it has been mined in 9 counties.

The following map of Indiana shows the locations of active coal mines that reported production for 1979. Mines are classified as surface or underground and according to yearly production. Table 1 is keyed to this map. After studying the map and Table 1, answer the following questions:

Activities:

Questions to Ask:

1. In which counties has most of the coal been mined? ____________________

   ____

   Figure 2 shows a map of the active coal mines in southwestern Indiana.

2. Where are most of the underground mines located? ____________________

   ____

3. Where are most of the strip mines located? ____________________

4. Where are the most productive underground mines located? ____________________

   ____

5. During the past 50 years production has been fairly consistent in Vigo, Sullivan, Pike, Greene, Clay, and Gibson counties because increase in strip mining offsets the decrease in underground mining. How do you think underground mining occurs?

   ____

   ____

Figure 2. Map showing active coal mines in Indiana.

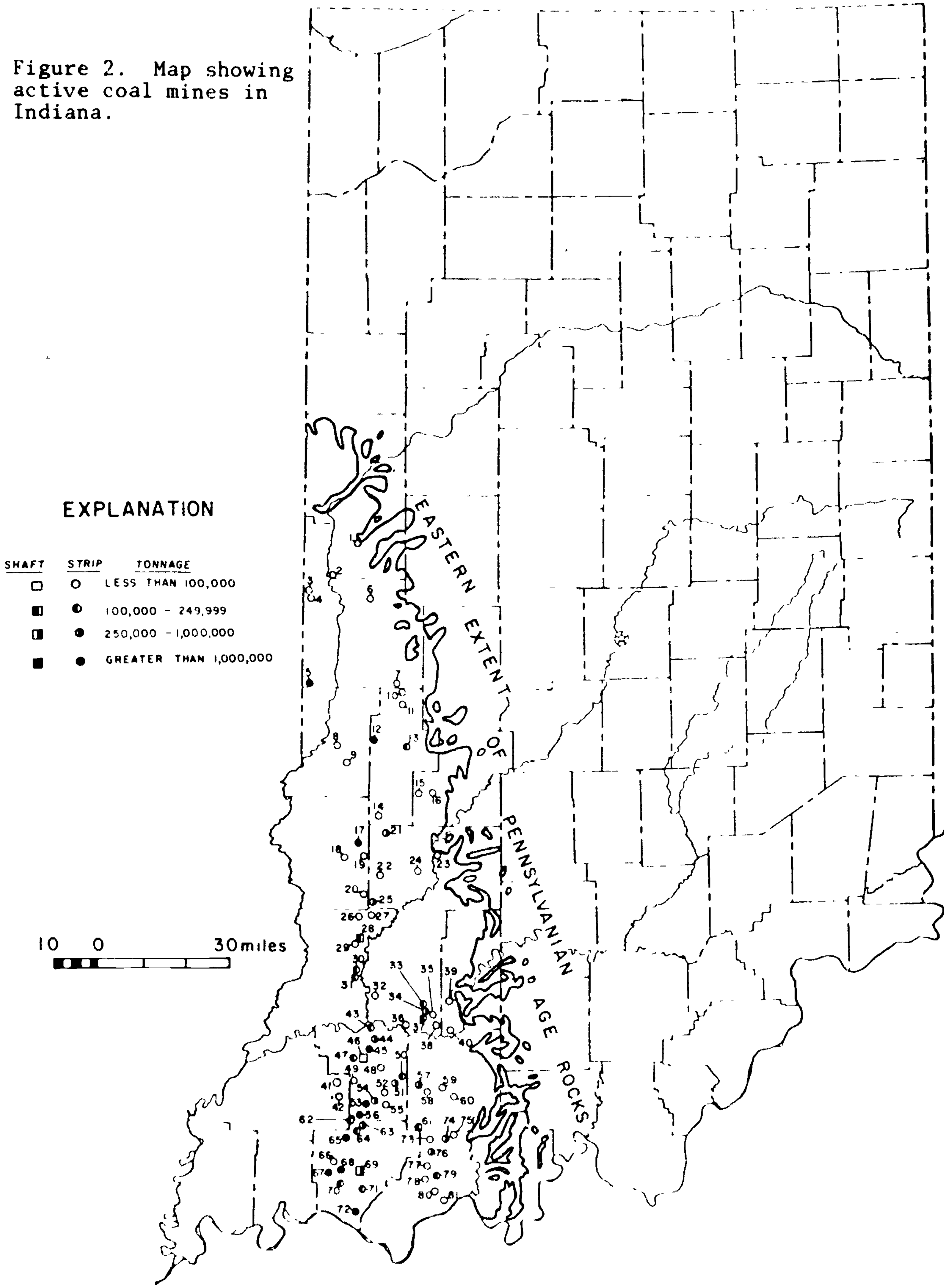


TABLE 1

Active Coal Mines in Indiana

Fountain County			
1) Shaw Pit No. 1	Shaw Contractors & Builders	Unnamed Staunton	Strip
2) Maple Grove No. 2	Maple Grove Coal Co.	Unnamed Staunton	Strip
Vermillion County			
3) Alver Pit No. 2	Alver Materials, Inc.	Bucktown (Vb)	Strip
4) Baird Pit	Eric Trousdale Coal Co.	Bucktown (Vb) & Springfield (V)	Strip.
5) Universal Mine	Peabody Coal Co.	Danville (VII)	Strip
Parke County			
6) Roaring Creek No. 1	Roaring Creek Coal Co., Inc.	Minshall & Block	Strip
7) Carbon Pit	Sun Mining Co.	Minshall	Strip
Vigo County			
8) Pit No. 1	S. & G. Excavating Co.	Springfield (V)	Strip
9) Rice Pit	J. H. & L. Coal Co.	Springfield (V)	Strip
Clay County			
10) E. & E. Pit	E. & E. Coal Co.	Block	Strip
11) Benwood (E. & K.) No. 1	Log Cabin Coal Co.	Block	Strip
12) Center Point No. 1	Brazil Coal & Clay Co.	Block	Strip
13) Chinook Mine	Amax Coal Co., Inc.	Seelyville (III)	Strip
14) Mine No. 3	P'Burg Coal Co.	Block	Strip
Owen County			
15) Pit No. 1	John & Robert Haviland	Springfield (V)	Strip
16) Hendricks No. 1	Hesco, Inc.	Springfield (V)	Strip
Sullivan County			
17) Minnehaha Mine	Amax Coal Co., Inc.	Danville (VII) & Hymera (VI)	Strip
18) Dugger Mine	Peabody Coal Co.	Danville (VII) & Hymera (VI)	Strip
19) Dugger Pit	Comet Coal & Clay Co.	Danville (VII)	Strip
20) Pit No. 2	Cousins Coal Co., Inc.	Hymera (VI)	Strip
Greene County			
21) Latta Mine	Peabody Coal Co.	Danville (VII); Hymera (VI) & Springfield (V)	Strip
22) Pit No. 1	Four C's, Inc.	Springfield (V)	Strip
23) Bredeweg	Winslow Coal Co.	Block	Strip
24) Lyons	Comet Coal & Clay Co.	Unnamed Staunton	Strip
25 Hawthorn	Peabody Coal Co.	Danville (VII)	Strip
26) Sam's Mine	Coal, Inc.	Springfield (V)	Shaft
Knox County			
26) Knox No. 5	Ohio Valley Co.	Danville (VII)	Strip
27) Newell No. 1 Pit	M. & T. Coal Co.	Springfield (V)	Strip
28) J. & R. Mine	J. & R. Coal Co., Inc.	Hymera (VI)	Strip
29) Apraw	Black Beauty Coal Co., Inc.	Hymera (VI)	Strip
30) No. 1 Pit	Bicknell Minerals Inc.	Danville (VII) & Hymera (VI)	Strip
31) Pit No. 7	Solar Sources Inc.	Danville (VII) & Hymera (VI)	Strip

Daviess County

32) No. 9 Pit	Solar Sources Inc.	Springfield (V)	Strip
33) Sugar Creek No. 1	Nancy Coal Co., Inc.	Unnamed Staunton	Strip
34) Graber No. 1	Mifflin Mining Co.	Buffaloville	Strip
35) A. & P. Pit	V. R. Leasing Corp.	Buffaloville	Strip
36) P. V. No. 2	P. V. Corp.	Seelyville (III)	Strip
37) A. M. C. No. 3	Central Utility Coal Co., Inc.	Buffaloville	Strip
38) Old Union Pit No. 1	Kentuckiana Energy Corp.	Mariah Hill	Strip

Martin County

39) Crowder Mine	Ronald L. Allen	Blue Creek	Strip
40) Pit No. 1	Great Ltd. Partnership	Blue Creek	Strip

Gibson County

41) Ross Pit No. 1	Barger Engineering, Inc.	Hymera (VI)	Strip
42) Brown Mine No. 2	B. F. C. Coal Co., Inc.	Danville (VII) & Hymera (VI)	Strip

Pike County

43) Redman	Joseph Mullen	Springfield (V)	Strip
44) Solar Sources No. 6	Solar Sources Inc.	Springfield (V)	Strip
45) Old Ben No. 2	Old Ben Coal Corp.	Hymera (VI) & Springfield (V)	Strip
46) R. & H.	R. & H. Mining Co., Inc.	Springfield (V)	Shaft
47) Reece Pit	Parke Coal Co.	Danville (VII)	Strip
48) White Oak	Mitch Parrish	Springfield (V)	Strip
49) Boyd No. 1	Will Construction Co., Inc.	Danville (VII) & Hymera (VI)	Strip
50) Pit No. 1	Hopf Mining Corp.	Colchester (IIIa) & Seelyville	Strip
51) Black Beauty	Black Beauty Coal Co.	Survant (IV)	Strip
52) Cherokee	Paul Shelton	Survant (IV)	Strip
53) Old Ben No. 1	Old Ben Coal Corp.	Springfield (V)	Strip
54) Blackfoot	Abbott Coal & Energy	Survant (IV)	Strip
55) Brown Pit No. 1	Coalgate, Inc.	Survant (IV)	Strip
56) E-Victor	English Coal Co.	Hymera (VI)	Strip

Dubois County

57) Neukom & Keusch	Old Erin Coal Co.	Unnamed Staunton	Strip
58) Pioneer	Delta Mining Corp.	Unnamed Mansfield	Strip
59) Berg No. 1	B. & M. Coal Co.	Buffaloville	Strip
60) Lords No. 1	Shaw Contractors & Builders	Unnamed Brazil; Unnamed Mansfield & Mariah Hill	Strip
61) Buse	Three States Trucking Co.	Unnamed Mansfield	Strip

Warrick County

62) North Lynnville	Four Rivers Coal Co.	Hymera (VI)	Strip
63) Pit No. 12	Sola Sources Inc.	Danville (VII) & Hymera (VI)	Strip
64) Roettger & Brown	Winslow Coal Co., Inc.	Danville (VII) & Hymera (VI)	Strip
65) Lynnville	Peabody Coal Co.	Danville (VII): Hymera (VI) & Springfield (V)	Strip
66) Millersburg	Will Construction Co.	Danville (VII) & Hymera (VI)	Strip

67) Ayrshire	Amax Coal Co., Inc.	Danville (VII) & Hymera (VI)	Strip
68) Squaw Creek	Squaw Creek Coal Co.	Danville (VII) & Hymera (VI)	Strip
69) Spur Mine	Peabody Coal Co.	Springfield (V)	Shaft
70) No. 13	Ohio Valley Co.	Hymera (VI)	Strip
71) Warner Pit	B. & M. Coal Corp.	Springfield (V)	Strip
72) Wright Mine	Amax Coal Co., Inc.	Springfield (V)	Strip

Spencer County

73) Spencer	Spencer Coal Corp.	Unnamed Brazil	Strip
74) No. 2 Mine	B. & L. S. Contracting, Inc.	Mariah Hill	Strip
75) Olinger Pit	Michael R. Altman	Unnamed Brazil	Strip
76) Mine No. 1	Energy Supply Co.	Unnamed Brazil	Strip
77) Ferguson	Delta Mining Corp.	Buffaloville	Strip
78) Nussmeier	Mulzer Crushed Stone Co.	Buffaloville	Strip
79) Criss Pit	Foertsch Construction Co., Inc.	Mariah Hill	Strip
80) Taylor Pit	Paul Shelton	Buffaloville	Strip
81 Varner Pit	B. & M. Coal Corp.	Mariah Hill	Strip

INDIANA COAL RESERVES

IN

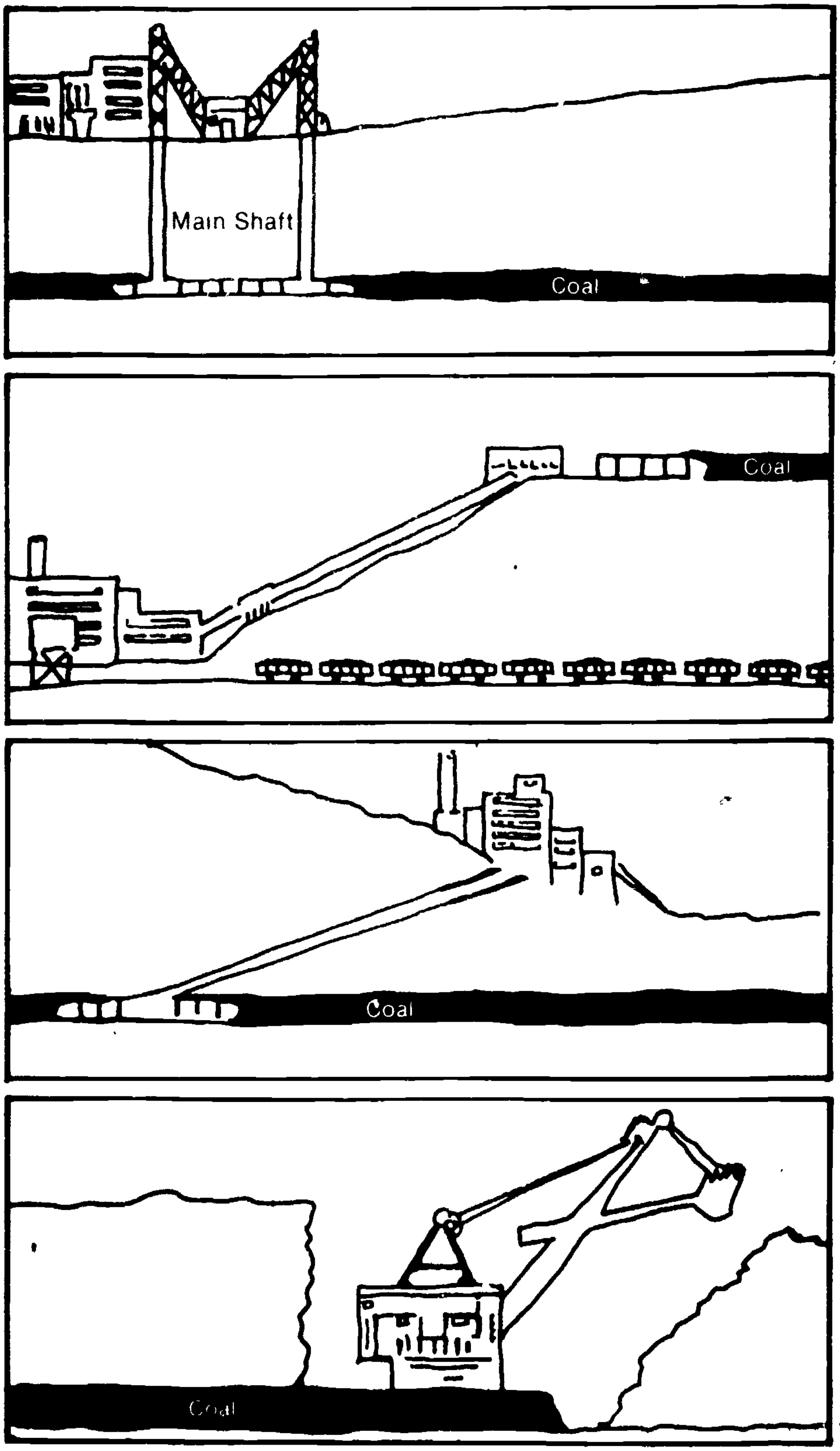
THOUSANDS OF SHORT TONS (JANUARY 1,1980)

Courtesy of Indiana Department of
Natural Resources, Geological Survey

COUNTY	TOTAL RESERVES JANUARY 1, 1965			PRODUCTION: 1965 - 1979			RECOVERABLE RESERVES* JANUARY 1, 1980		
	STRIP	NONSTRIP	TOTAL	STRIP	NONSTRIP	TOTAL	STRIP	NONSTRIP	TOTAL
CLAY	404119	504731	908850	15502	0	15502	307793	252366	560159
DAVIESS	171301	239004	410305	2005	0	2005	135036	119502	254538
DUBOIS	5997	7956	13953	2171	1	2172	2627	3977	6604
FOUNTAIN AND WARREN	40717	7204	47921	416	0	416	32158	3602	35760
GIBSON	525	4473327	4473852	993	6052	7045	0	2230612	2230612
GREENE	267198	456795	723993	14321	147	14468	199437	228251	427688
KNOX	177856	4482971	4660827	1973	515	2488	140312	2240971	2381283
MARTIN	103464	22	103486	132	0	132	82639	11	82650
OWEN	63489	0	63489	245	0	245	50546	0	50546
PARKE	11964	59004	70968	87	0	87	9484	29502	38986
PERRY	485	55915	56400	565	0	565	0	27958	27958
PIKE	311313	740936	1052249	69256	911	70167	179794	369557	549351
POSEY	0	5740781	5740781	0	0	0	0	2870391	2870391
SPENCER	66365	3	66368	7447	0	7447	45645	2	45647
SULLIVAN	392454	6981147	7373601	41089	8237	49326	272874	3482337	3755211
VANDERBURGH	0	2166909	2166909	0	0	0	0	1083455	1083455
VERMILLION	57492	588706	646198	22860	17	22877	23134	294336	317470
VIGO	319476	2898412	3217883	5821	774	6595	249760	1448432	1698192
WARRICK	405019	1034808	1439827	121498	2094	123592	202517	515310	717827
TOTALS	2799234	30438631	33237865	306381	18748	325129	1933846	15200572	17134328

*RESERVE CALCULATIONS ASSUMED A 20 PERCENT LOSS BY STRIP MINE PRODUCTION AND A 50 PERCENT LOSS BY NONSTRIP (UNDERGROUND) MINE PRODUCTION.

Figure 3. Four types of bituminous coal mines. Although Indiana has mainly surface mining, a few underground mines do exist.



Shaft Mine

Drift Mine

Slope Mine

Surface Mine

Types of Underground Mines

There are three types of underground mines: shaft mines, drift mines, and slope mines. In most underground mines, the undercutting is done by electrically powered cutting machines that look like giant chain saws. Then the coal is loosened by blasting. Leading machines scoop up the loosened coal. They dump the coal onto a moving belt or into a waiting shuttle car which starts it on its trip out of the mine. In a shaft mine, the moving belts or shuttle cars carry the coal to the base of the shaft. Elevators then lift the coal out of the mine. In a drift mine, the moving belts or shuttle cars carry the coal straight out to the mine entrance in the side of the hill. In a slope mine, the coal is carried out of the mine by moving belts or electric railways that travel from the coal seams, along the slope tunnel, to the surface.

At some point the cost of underground mining will become less expensive than stripping and the coal production of underground mines will increase. But there exist current problems with our foremost method of mining.

Activities

1. In any one area, strip mines and underground mines are in constant competition. On the average, coal can be mined at a lower cost by stripping than by underground mining. Can you explain how this is possible?

   ____

   ____

   Why would using just one method be cheaper? ______________

   ____

2. As the shallower and thicker coalbeds become mined out and mines must produce from deeper and thinner coals, stripping costs increase. If stripping becomes expensive, what do you think the coal companies would do?

   ____

   ____

3. Mining companies will balance the increased cost per ton by strip mine methods because of increased overburden ration, increased reclamation (returning the land to a useful purpose), and increased mine safety costs. On the basis of these findings the company can decide whether the coal that is 75-150 feet deep should be strip mined or mined underground. Predict what you think will happen in the future with strip and underground mines:

   ____

   ____

4. Ask students, "How long will the strippable reserves last?" It is likely that the amount of coal mined by stripping each year will continue to increase and then start decreasing. How do you think that this will happen?

5. In strip mines 80-90% of the coal in the bed can be sent to market, whereas in deep mires as much as 50% of the coal must be left for pillars to support their overhead. How is underground mining more dangerous than surface mining?

6. What are some problems associated with the mining and burning of coal? (Air pollution, water pollution, soil erosion, acid rain, wildlife, habitat, etc...)

7. How can we reduce these problems? (Better reclamation practices, scrubbers, wildlife habitat improvement, etc...)

8. Have a debate - 1 side, pro strip mining; second side, pro underground mining.

9. Make a mural - "from the mine to me."

10. Make up their own coal crossword puzzle (across and down - e.g. "the kind of coal prominent in Indiana" - Bituminous).

11. Use the maps of the railroads and other mineral resources in Indiana and the location of the mines to see if they correspond in location.

12. Discuss how coal was first used/discovered?

13. Have students list ways coal is used.

14. Investigate the difference between surface mines and underground mines. List the pros and cons of each, and be ready to defend one and justify your choice.

15. Discuss/investigate why some coal deposits in Indiana will never be mined. (the coal is an inferior grade and the seams are too thin to make mining economical).

EECP
Unit VI
Lesson K

LESSON TITLE: Problems with Coal and Solutions

LESSON OBJECTIVE

Students will become aware of problems associated with coal mining and solutions being proposed and researched.

BACKGROUND INFORMATION - See Attached

ACTIVITIES - See Attached

RESOURCES

Coal Minicourse, National Science Foundation, Pre-college Teacher Development in Science Program The Geosciences Today, Purdue University, Department of Geosciences, West Lafayette, Indiana 47907.

Indiana Bureau of Mines and Mining
125 South 15th Street
Terre Haute, Indiana 47807

Indiana Department of Natural Resources
Geological Survey
611 North Walnut Grove
Bloomington, Indiana 47405

Background Information

Problems With Coal

How long will our coal reserves last? Forever?

No reserves are eternal. Regardless of mining method, if coal mining continues at about the present rate, Indiana's coal reserves will last for 800 years. If we assume that mining in Indiana will increase 10% each as predicted, almost all of our coal will be mined in another 50 years.

If, as predicted, Indiana changes from surface mines to underground mines, it will be an expensive change. Explain:

___

___

To develop a new deep mine producing two million tons of coal per year with a 20 to 30 year life span can require five to seven years and an investment of $60 million or more. Mine expansion is similarly time consuming and costly.

There is great controversy over strip mining as well as coal mining. Explain:

___

___

We have already discussed the problem of reclamation and spoiled land in previous lessons. Because of the new laws, coal companies are making good use of the land. It is a problem of higher cost.

Other problems are the health and safety of the miners. State and federal laws and regulations, such as the U.S. Coal Mine Health and Safety Act, as well as company safety rules, impose elaborate safety precautions on every phase of mining. Company officials make health and safety inspections daily. Federal and state agencies also conduct extensive inspections.

The concentration levels of dust in underground mines are tested and medial authorities agree that the concentrations are not harmful.

Accidents are a continual concern. However, the number of fatal accidents each year has fallen since 1970. U.S. mines today are safer places to work than they have ever been. Coal operators, miners and the government continue to review problem areas to improve the working environment.

What about air pollution? Coal is a valuable resource, but it creates by-products during combustion that can, in sufficient quantity, pose environmental problems. Sulfur emissions are thought to be one of the most important of these by-products, and Indiana coal reserves are classified as being "high sulfur." One of the approaches to reducing sulfur emissions is to use low sulfur fuels. Another is the chemical removal of sulfur oxides before and after combustion. Coal can also be made less polluting by cleaning it before burning. This method includes cleaning by gravity techniques which use the differences in the specific gravities of the pyrite in coal and the coal itself to separate the two. Also used are the washing of coal with water and with froth flotation, which adds chemicals to remove sulfur.

"Stack gas scrubbers" are cleansing tanks that remove most of the sulfur from the gases going up the stack. A thick sludge forms which settles to the bottom of the tanks. This is drawn off and transported to sludge ponds.

The Federal Clean Air Act requires all new coal-fired power plants and industrial facilities be equipped with the best available control technology. Today, that is interpreted to mean scrubbers, and they may add anywhere from 18-35% to the cost of building and operating an electric generating station. What will that do to consumers' bills?

Many other methods of controlling the emission of particles are being researched. For example, electrostatic precipitators are used to control air pollution. A long term possibility is the magnetohydrodynamic (MHD) system. In this process, coal and preheated air are fed in a burner at very high temperatures. Potassium salts are added, producing a gas of high conductivity. The gas is then passed through a magnetic field producing electricity. The hot gasses are exhausted to a steam-boiler. Through procedures such as this, Indiana coal, even with its sulfur content, will always be a good investment and an environmentally sound form of energy.

New Technologies Research/Solutions:

In order to make electricity production from coal cleaner and more efficient, new technologies are being developed. These include chemical coal cleaning, coal hydrogenation (to produce liquid fuel from coal), fluidized-bed combustion (to capture sulfur ahead of the exhaust stack), and coal gasification integrated with combined cycles (converting coal to a low or intermediate-BTU gas and then extracting its energy through gas and steam turbines in tandem). Each of these technologies offers different performance and economic incentives.

Fluidized-bed combustion has potential for making the greater use of high sulfur coal possible. It is still expensive, but will probably be in wide use later in this century.

Coal liquification produces synthetic crude oil out of coal. The electric utility industry is vitally concerned with this process because petroleum fuels are going to become less available and the industry is dependent on petroleum for certain generating uses.

Coal gasification is a process by which coal is turned into a gas. Some techniques for doing this have been known and used for many years, but the gas they produce is expensive. Now, with natural gas becoming increasingly scarce and more expensive, there is renewed interest in developing new means for transforming coal into gas.

Looking Ahead

Coal mined in Indiana competes for the fuel market with coal mined in nearby states and with natural gas, petroleum, and nuclear energy. If the coal is converted to gas, gasoline, and chemical raw materials, it will compete with the same areas of production and with the same natural resources. Whether coal production in Indiana increases or decreases depends on how well the coal industry meets the challenge of research: whether it can increase efficiency in mining preparation and utilization, whether it can make coal more useful, and whether it can produce breakthroughs in technology that will allow coal to be converted into unique products that have a large demand. A principal objective of the U.S. energy policy is to develop the technology that will enable coal to be substituted for fuels in short supply. A major factor in favor of coal in the long-term competitive struggle is the fact that we have much larger reserves of coal than we have of oil and gas. Indiana has significant coal reserves and is in a good location with regard to population density and coal use.

Activities

1. **Field Trip to a Coal Mine**

   After making arrangements to visit the nearest coal mine in the locality, the teacher should distribute to students the following "Field Trip Work Sheets." Students should review the worksheets prior to the trip to familiarize themselves with what they should be observing and researching.

   By visiting a coal mine students have the opportunity to see the mining in actual operation and then possibly develop their own solutions to problems associated with coal mines and types of mining.

2. What is the focus point of the coal mine?

3. Describe how you felt when you first entered the mine property?

4. Take photographs of land at a particular mine site before being stripped, during and after. Compare and contrast. (Take several different shots of each)

5. Find out how the coal companies discovered coal reserves in the first place. How do they know where it begins and ends and where to mine? (3 ways they (geologists) discover where it is located: 1) core drillings, 2) outcrops, 3) coal uncovered through excavations such as highway construction)

6. Look at:

   a. land before mining (write down observations. Infer the order of the layers. Hypothesize what the land will be used for after being stripped).

   b. land during active mining (write down observations, inferences, hypothesis).

   c. land after it has been stripped (observe, infer, hypothesize).

d. land after reclamation (observe, infer (method used), hypothesize, predict future use).

7. Obtain samples of coal types. Classify the types according to appearance. Why does the coal look like it does? How many types and which types occur in Indiana? How does it feel? hard or soft? Why does it look like it does (fossils)?

8. Have a simulation of a news reporter interviewing various miners and workers at the mine.

9. Divide the class into small groups to discuss why and how coal miners strike. Then get together as a large group and discuss (or two groups):

   a. miners
   b. coal companies

   Act out what they expect of each other.
   Hypothesize how strikes affect miners and families and how they affect others (industry, schools, homes). Role play.

More Suggested Activities

-Draw a picture of what a mine looks like after being stripped and reclaimed.

-Students brainstorm about how to use the land after strip mining.

-Set up a debate in class pro-strip mining vs. anti-strip mining (environmental)

-Students pretend that they are miners writing about their day to a friend.

-Develop a coal awareness program for the rest of the school. Have individual students choose an aspect of Indiana coal according to their interests for informing the school. For example, one person could create an activity-oriented bulletin board about the uses of coal. Topics you may wish to have covered will be:

1) how coal was formed
2) the life of a coal miner
3) coal and the environment
4) coal and its uses
5) reclamation
6) the future of coal
7) location of coal in Indiana
8) coal and electricity
9) the safety measures taken in underground mines
and any other topics students may choose

Class may want to start from scratch and make own list.

This could be the [illegible] of the unit on coal.

-(The Lebanon) Coal Cavern - fix the room up like a museum. For example, when people first enter the room it looks like an underground mine. Each student, having chosen a topic (from the beginning of coal in Indiana to the uses of coal today and new reclamation laws), will have his own display. "Tour guides" will lead the visitors from exhibit to exhibit. Each "guide" explains his own exhibit. The students may even choose to dress as people from "coal towns."

-Graph the [illegible] in Indiana counties.

-Have [illegible] magazine and newspaper articles related [illegible] "[illegible] Scoop with Coal" bulletin board.

-[illegible] company and environmental[illegible]

Have [illegible]
C [illegible]
O [illegible]
A [illegible] which we have none
L [illegible] load of this coal.

-Create their own songs to familiar tunes, (e.g. to the tune of Oscar Meyer Wiener)

O I wish I were a piece of Bituminous Coal
That is what I truly want to be
For if I were a piece of Bituminous Coal
Everyone would get a charge from me.

O I wish I were a piece of Anthracite Coal
That is what I truly want to be
For if I were a piece of Anthracite Coal
Everyone would make a fuel of me.

(to the tune of "Take Me Out to the Ball Game")

Coal Miner's Lament

Take me out to the coal mine
Take me out to the pits
Give me my lunchbox and hard hat
I don't care if I never come back
For it s drag, drag, drag for the dragline
If you give up it's a shame
For it's 1, 2, 3, million we're out in the old coal game.

-Have students (small group) develop a game about Indiana coal, e.g. a board game, card game, using what they learn - good review for a test.

-Invent a new energy source with details on how it was formed, possible uses, pros and cons, environmental restrictions.

-Make up a dictionary or resource book with coal terminology.

-What will the town of ________________ be like in 50 years? 100 years? Will coal be a dominant energy source?

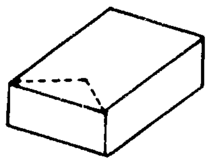
-Have an "ask it machine" - a large cardboard box. Each student can submit a question relating to coal, energy. Divide the class into two teams. Each player gets one turn to pick a question from the weird machine. Can answer it in fact or fiction.

-Keep track of how many kwh you use in one week. It takes about one ton of coal to produce 2,000 kwh. Figure out how many kwh you use during a billing period, and then figure the number of pounds of coal used. How can you save the use of coal?

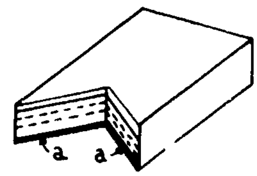
-Use news stories as a base for a poem by having students pull desired material from the article and rewrite it in poetry from modeling it after a song. Can also write limericks.

-Coal Reserve Activity- cut-away of coal mine. Materials: shoe box or other similar shaped box, recipe for salt-flour mixture.

(1)



(2)



1) cut box as shown
2) tape pieces of cardboard over V, (see a)
3) Mix flour-salt mixture (3 parts salt and one part flour with enough water to bring solution to consistency of dough) and cover box <u>completely</u>. Dye layers according to layers of land.

Bibliography

Sources Used:

American Institute of Mining, Metallurgical and Petroleum Engineers
345 East 47th Street
New York, NY 10017

American Petroleum Institute
2101 L. Street, Northwest
Washington, D.C. 20037

Coal Energy and Crisis by Lillie D. Chaffin, Harvey House, New York, NY, 1974.

"Coal Resources of Indiana" by C.E. Weir, Indiana Geological Survey Bulletin 42-1, 1973.

Department of Horticulture, Purdue University, Dr. Phil Carpenter, (reclamation).

The Earth's Story by Gerald Ames and Rose Wyler.

Energy Education Minicourse, Geosciences 102, by Janine Cokain, Kathy Dickerson, Cindy Fithian, and Gerald Krockover, 1977.

Energy Research and Development Administration
Office of Public Affairs
Washington, D.C. 20545

Excursions in Indiana Geology by Ann M. Burger, Carol B. Rexroad, Allan F. Schneider, and Robert H. Shaver, Department of Natural Resources, Geological Survey Guidebook 12, Bloomington, Indiana, 1966.

Exxon Corporation
Department B
P.O. Box 4125
Grand Central Station
New York, NY 10017

Federal Bureau of Mines Liaison Office
Seventh and College Streets
Bloomington, Indiana 47401

"The Gloom in Coal," Business Week, November 28, 1977.

The Great Energy Search by Elaine Israel, Julian Messner, New York, NY, 1974.

Indiana Bureau of Mines and Mining
1119 Wabash Avenue
Terre Haute, IN 47807

Indiana Geological Survey
611 North Walnut Grove
Bloomington, IN 47401

"Mined-Land Reclamation in the Interior Coal Province," by Allen T. Grandt, *Journal of Soil and Water Conservation*, March-April, 1978.

National Coal Association
1130 17th Street, N.W.
Washington, D.C. 20036

Reclamation Office
Indiana Department of Natural Resources
P.O. Box 126
Jasonville, Indiana 47438

"A Second Coal Age Promises to Slow Our Dependence on Imported Oil," *Smithsonian*, August, 1977.

"Surface-Mined Land in the Midwest: A Regional Perspective for Reclamation Planning," Prepared for the U.S. Department of the Interior, June, 1974.

"Surface Mining in Indiana," by Mark L. Williams, *Indiana*, Summer, 1977.

The Whole Earth Energy Crisis: Our Dwindling Sources of Energy, by John H. Woodburn.

Magazines:

Watch these magazines for current findings and updates:

The Hoosier Science Teacher

Indiana
Indiana Department of Commerce

Journal of Geologic Education
c/o Allen Press, Inc.
P.O. Box 368
Lawrence, KS 66044

Journal of Soil and Water Conservation
Soil Conservation Society of America
75105 N.E. Ankeny Road
Ankeny, IO 50020

Outdoor Indiana
Indiana Department of Natural Resources
Room 612, State Office Building
Indianapolis, IN 46204

Popular Science
380 Madison Avenue
New York, NY 10017

Science
1515 Massachusetts Avenue, NW
Washington, D.C. 20005

Science Activities
400 Albemarle Street
Washington, D.C. 20016

Science Teacher
1742 Connecticut Avenue, N.W.
Washington, D.C. 20009

Scientific American
415 Madison Avenue
New York, NY 10017

Smithsonian
900 Jefferson Drive
Washington, D.C. 20560

For Tours of Indiana Surface Coal Mines contact:

Indiana Coal Association
632 Cherry Street
Terre Haute, Indiana 47801

Where to Call:

Additional information on coal and answers to questions are available from the following government agencies and private organizations:

Bituminous Coal Research, Inc.
Monroeville, PA (412) 327-1600

Edison Electric Institute
Washington, D.C. (202) 862-3800
New York, NY (212) 573-8741

National Coal Association
Washington, D.C. (202) 628-4322

U.S. Department of Energy
Office of Public Affairs
Washington, D.C. (301) 353-5660

U.S. Department of Interior
Bureau of Mines
Washington, D.C. (202) 343-1100

Also, the electric company that provides service in your area.

Doty, Ray. "Where Are You Going With That Coal?" Doubleday and Company, Inc. Garden City, New York, 1977.

PLEASE TELL US WHAT YOU THINK ABOUT THE SENIOR HIGH SCHOOL ENERGY MATERIALS

Your position: ______teacher
(check) ______dept. head
______administrator
______other

Your grade level: ______________
Subject(s) taught: ______________
____

If possible, please answer these questions after you have taught unit lesson(s) in your class and examined teacher's guide. If this is not possible, please answer based on your personal inspection of the unit materials.

1. What project materials are you evaluating? (Check all that apply)
______Unit I ______Unit VI
______Unit II ______Unit VII
______Unit III ______Unit VIII
______Unit IV ______Unit IX
______Unit V ______Teacher's Guide

2. What is the basis for this evaluation? (Check all that apply)
______(1) teaching 4 or more lessons
______(2) teaching 1 to 3 lessons
______(3) personal inspection
______(4) discussion with others who know materials

3. Have you shared these units with other educators? (Check one)
______(1) No
______(2) Yes, with 1-4 others
______(3) Yes, with 5-10 others
______(4) Yes, with more than 10

Circle the number from 1 (Definitely No) to 7 (Definitely Yes) which best reflects your answer.

	DEFINITELY NO			NEUTRAL			DEFINITELY YES
4. Are these materials easy to understand and use?	1	2	3	4	5	6	7
5. Do these materials fit with the curriculum of your district?	1	2	3	4	5	6	7
6. Are you likely to make use of these materials in the future?	1	2	3	4	5	6	7
7. Are these materials appropriate for the level of your students?	1	2	3	4	5	6	7
8. Are these materials interesting to your students?	1	2	3	4	5	6	7
9. Is the reading level appropriate?	1	2	3	4	5	6	7
10. Do you think these materials will reduce energy consumption?	1	2	3	4	5	6	7

What did you like best? ______________

What did you like least? ______________

Suggestions/Comments (Use the back as needed): ______________

RETURN TO: Energy Education Curriculum Project, Division of Curriculum, Department of Public Instruction, Room 229, State House, Indianapolis, IN 46204.